



Technology for Large Space Systems

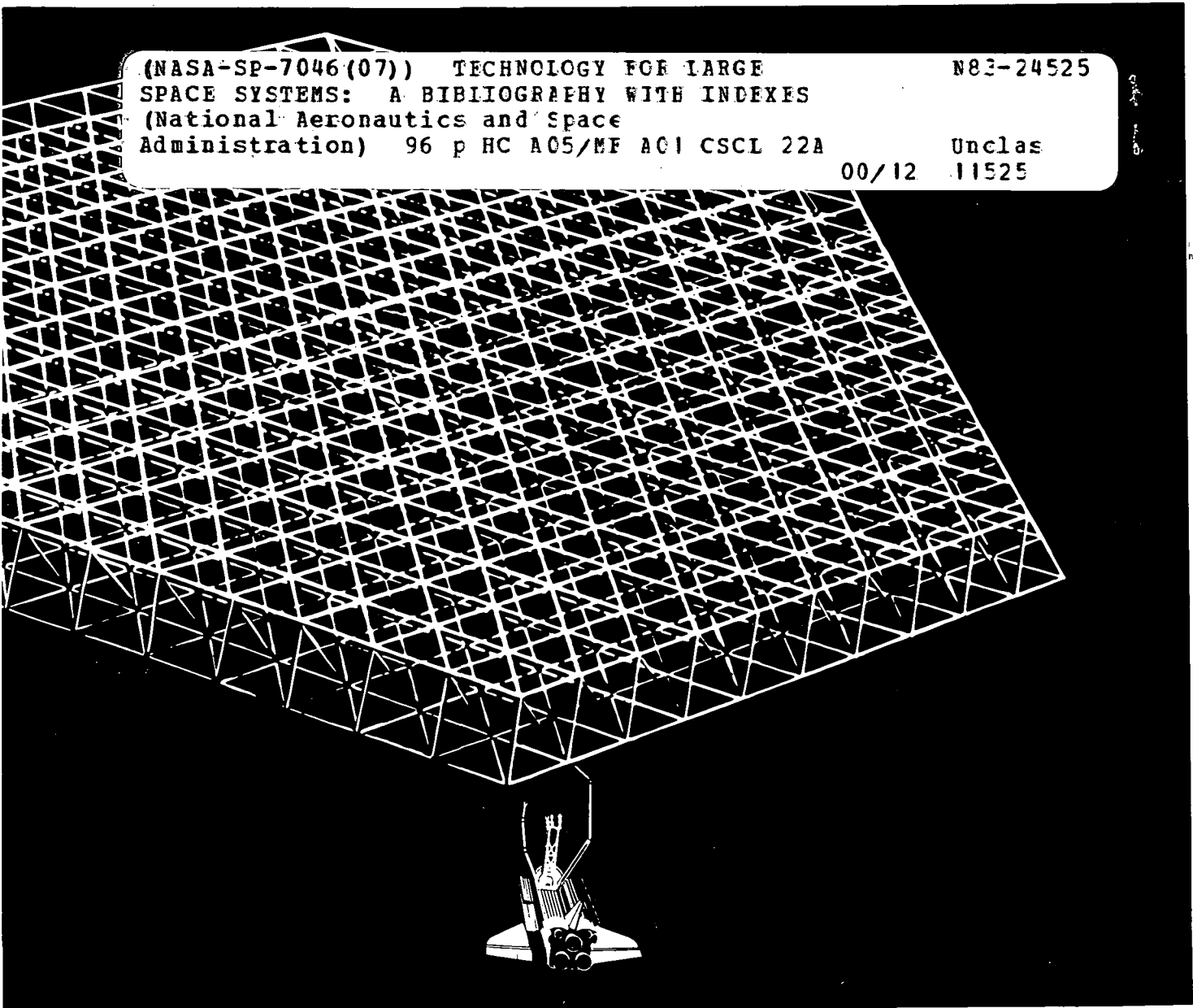
NASA SP-7046(07)
January 1983

A Bibliography
with Indexes



25th Anniversary
1958-1983

(NASA-SP-7046(07)) TECHNOLOGY FOR LARGE SPACE SYSTEMS: A BIBLIOGRAPHY WITH INDEXES (National Aeronautics and Space Administration) 96 p HC A05/MF A01 CSCL 22A N83-24525
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TECHNOLOGY FOR LARGE SPACE SYSTEMS

A BIBLIOGRAPHY WITH INDEXES

Supplement 7

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system between January 1 and June 30, 1982 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*



Scientific and Technical Information Branch

1983

National Aeronautics and Space Administration

Washington, DC

NOTE TO AUTHORS OF PROSPECTIVE ENTRIES:

The compilation of this bibliography results from a complete search of the *STAR* and *IAA* files. Many times a report or article is not identified because either the title, abstract, or key words did not contain appropriate words for the search. A number of words are used, but to best insure that your work is included in the bibliography, use the words *Large Space Structures* somewhere in your title or abstract, or include them as a key word.

This supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161 at the price code A06 (\$13.00 domestic; \$26.00 foreign).

INTRODUCTION

This bibliography is designed to be helpful to the researcher and manager engaged in developing technology within the discipline areas of the Large Space Systems Technology (LSST) Program. Also, the designers of large space systems for approved missions (in the future) will utilize the technology described in the documents referenced herein.

This literature survey lists 366 reports, articles and other documents announced between January 1, 1982 and June 30, 1982 in *Scientific and Technical Aerospace Reports (STAR)*, and *International Aerospace Abstracts (IAA)*.

The coverage includes documents that define specific missions that will require large space structures to achieve their objectives. The methods of integrating advanced technology into system configurations and ascertaining the resulting capabilities is also addressed.

A wide range of structural concepts are identified. These include erectable structures which are earth fabricated and space assembled, deployable platforms and deployable antennas which are fabricated, assembled, and packaged on Earth with automatic deployment in space, and space fabricated structures which use pre-processed materials to build the structure in orbit.

The supportive technology that is necessary for full utilization of these concepts is also included. These technologies are identified as analysis and design, structural dynamics and control, electronics, advanced materials, assembly concepts, and propulsion.

A Flight Experiments category and a General category complete the list of subjects addressed by this document.

The selected items are grouped into ten categories as listed in the Table of Contents with notes regarding the scope of each category. These categories were especially selected for this publication and differ from those normally found in *STAR* and *IAA*.

Each entry consists of a standard bibliographic citation accompanied by an abstract where available, and appears with the original accession numbers from the respective announcement journals.

Under each of the ten categories, the entries are presented in one of two groups that appear in the following order:

- 1) *IAA* entries identified by accession number series A82-10,000 in ascending accession number order;
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After the abstract section there are six indexes - subject, personal author, corporate source, contract number, report number, and accession number.

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All publications abstracted in this Section are available from the Technical Information Service, American Institute of Aeronautics and Astronautics, Inc. (AIAA), as follows: Paper copies of accessions are available at \$8.00 per document. Microfiche⁽¹⁾ of documents announced in *IAA* are available at the rate of \$4.00 per microfiche on demand, and at the rate of \$1.35 per microfiche for standing orders for all *IAA* microfiche.

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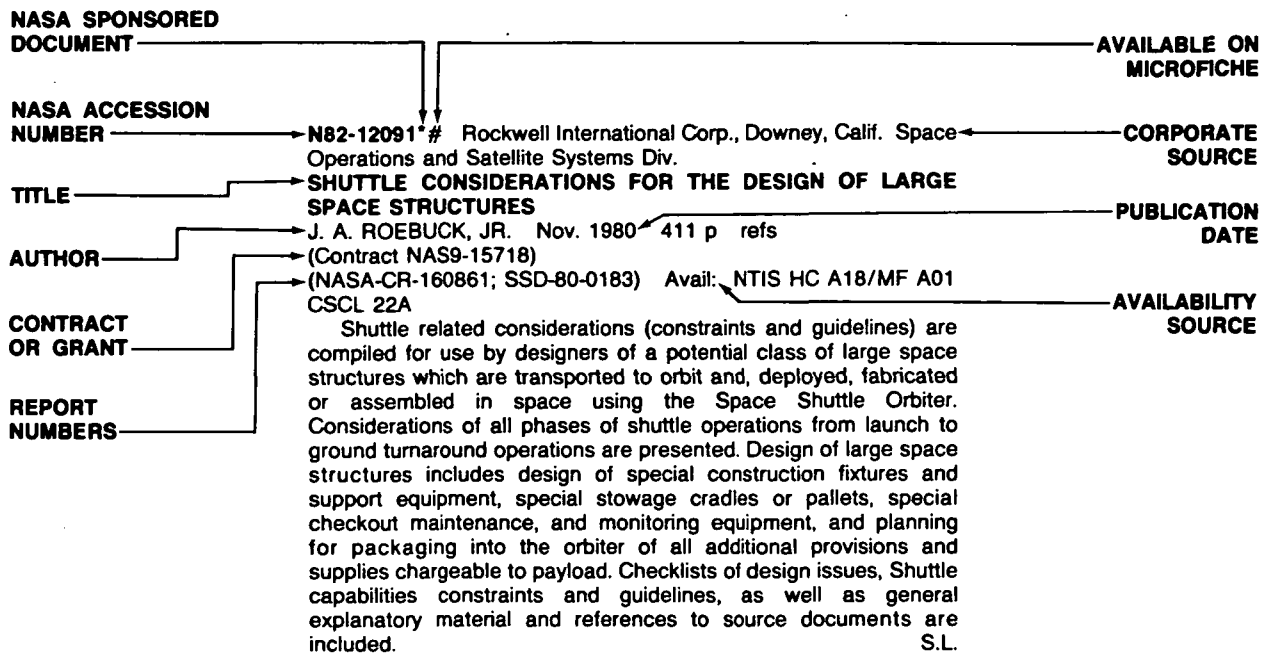
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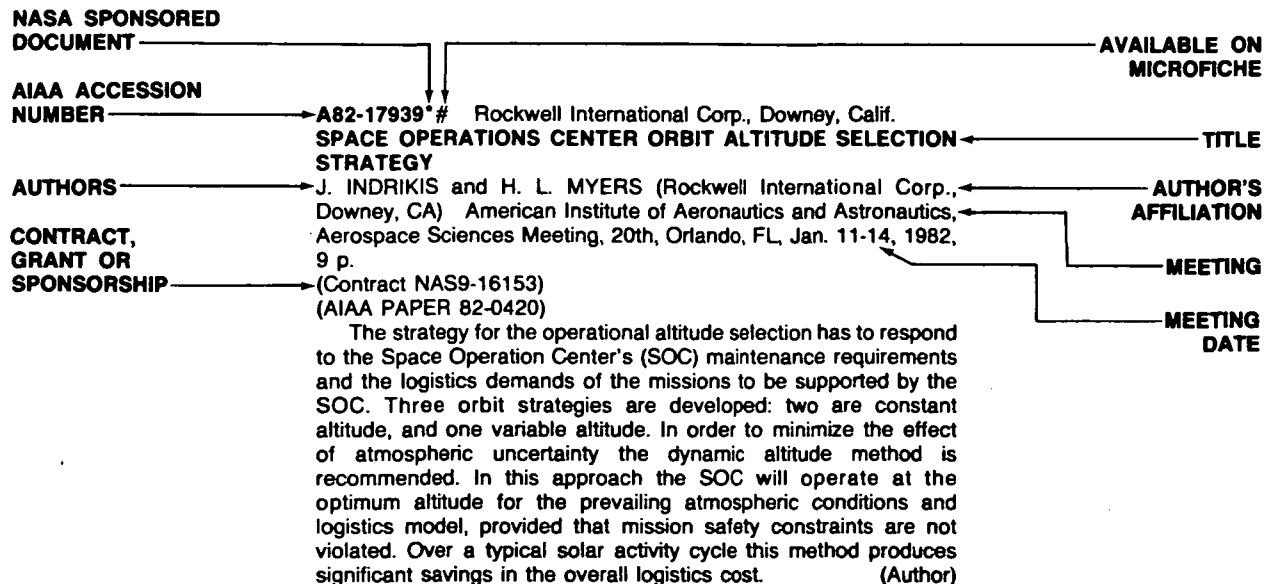
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TECHNOLOGY FOR LARGE SPACE SYSTEMS

A Bibliography (Suppl. 7)

JANUARY 1983

01

SYSTEMS

Includes mission and program concepts and requirements, focus missions, conceptual studies, technology planning, and systems analysis and integration.

A82-10089*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SPACECRAFT COMPUTER RESOURCE MARGIN MANAGEMENT

B. T. LARMAN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) In: Computers in Aerospace Conference, 3rd, San Diego, CA, October 26-28, 1981, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1981, p. 97-103. NASA-supported research. refs

(AIAA 81-2123)

The conduction of the Project Galileo Orbiter, with 18 microcomputers and the equivalent of 360K 8-bit bytes of memory contained within two major engineering subsystems and eight science instruments, requires that the key onboard computer system resources be managed in a very rigorous manner. Attention is given to the rationale behind the project policy, the development stage, the preliminary design stage, the design/implementation stage, and the optimization or 'scrubbing' stage. The implementation of the policy is discussed, taking into account the development of the Attitude and Articulation Control Subsystem (AACS) and the Command and Data Subsystem (CDS), the reporting of margin status, and the response to allocation oversubscription. G.R.

A82-11744*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

ANTENNA OPTIMIZATION AND COST CONSIDERATION FOR THE SOLAR POWER SATELLITE MICROWAVE SYSTEM

E. M. KERWIN, J. H. SUDDATH, and G. D. ARNDT (NASA, Johnson Space Center, Houston, TX) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings, Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 272-277. refs

The sizing, criteria, cost analysis, and optimized taper of the Solar Power Satellite (SPS) transmitting antenna are discussed. The sizing parameters considered were a thermal limit of 23 kW/sq m in the antenna, a peak power density of 23 mW/sq cm in the ionosphere, and cost effectiveness. Cost schedules and equations are presented for the SPS, and four antenna tapers are analyzed and compared, including the reference 10 dB Gaussian taper. An even powered quadratic series is formulated to minimize electricity cost and stay within thermal and ionospheric power level limits. The optimized Johnson Space Center taper is found to display the lowest energy costs, 4% below the 10 dB Gaussian, and can deliver 5.69 GW at 45.4 mills/kWh to the grid. Further studies are indicated for the optimal antenna and rectenna sizes M.S.K.

A82-11746#

APPLICATIONS OF POWER BEAMING FROM SPACE-BASED NUCLEAR POWER STATIONS

J. R. POWELL, T. E. BOTTS (Brookhaven National Laboratory, Upton, NY), and A. HERTZBERG (Washington, University, Seattle, WA) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings, Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 288-295. Research supported by the U.S. Department of Energy. refs

Power beaming from space-based nuclear reactors to earth, aircraft, or spacecraft is offered as an alternative to the SPSS. A rotating bed reactor (RBR) is described, in which the nuclear fuel is an annular bed of small particulates held in a rotating basket through which a coolant passes. Advantages over a previous nuclear rocket program, NERVA, are given as minimized size, external moderation and reflection, and several GW available from a reactor about one cu m in size. Testing of a model fluidized bed is described, noting favorable results from U-233 fuel, a projected 50 cm diam bed, and total mass of 3 metric tons. Two Brayton cycle generator systems are examined, and it is found that a turbine inlet temperature of 2,000 K and a simple Brayton cycle without regeneration yields a best efficiency of 30%. The RBR components are discussed, and microwave and laser power beaming systems are compared; economic projections indicate laser beaming to cruising aircraft is competitive with current jet fuel use. M.S.K.

A82-11758*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

HIGH PERFORMANCE SILICON SOLAR ARRAYS EMPLOYING ADVANCED STRUCTURES

D. E. ROCKEY (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA), J. M. HEDGEPEETH, and L. ADAMS (Astro Research Corp., Carpinteria, CA) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings, Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 374-379. refs (Contract NAS7-100)

Specific design features to reduce cell mass, lower panel operating temperatures, and improve power to mass ratios for silicon solar cell arrays in space applications are presented. Because mass constraints limit payload capacity for launch into GEO, graphite/epoxy structures combined with high performance Si cells are needed to deliver a power/mass ratio of 265 W/kg, notably for Solar Electric Propulsion systems, compared with existing level of 65 W/kg. Shallow diffusion and back surface field cell technology have raised cell efficiencies to 15%, with a back emissivity of 1.64. Structural design requirements comprise Shuttle interface compatibility, full ground test capability, low mass, and high stiffness. Three array alternatives are discussed, and the STACBEAM configuration, which consists of a triangular truss and a piston deployer with folding accomplished on simple hinges, provides 0.2 Hz stiffness and achieves the design power/mass goals. D.H.K.

A82-11769*# TRW Defense and Space Systems Group, Redondo Beach, Calif.

POWER MANAGEMENT OF MULTI-HUNDRED KILOWATT SPACECRAFT POWER SYSTEMS

D. K. DECKER, G. W. FLECK (TRW Defense and Space Systems Group, Redondo Beach, CA), and J. GRAVES (NASA, Marshall Space Flight Center, Huntsville, AL) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 434-439.

A NASA-sponsored study of space power distribution system technology is in progress to develop an Autonomously Managed Power System (AMPS) for large space power platforms. The conceptual design of a 250 kW photovoltaic power system, including the power management subsystem (PMS), is presented. A PMS concept is derived based on the need to accommodate the increased complexity of a utility-type power system, and to minimize Shuttle resupply and ground station operational costs. The main PMS functions are discussed along with the control strategies of the autonomously managed power system. (Author)

A82-11839#

ADVANCED SATELLITE POWER SYSTEM /SPS/ CONCEPT

W. V. MCRAE and G. M. HANLEY (Rockwell International Corp., Space Operations and Satellite Systems Div., Seal Beach, CA) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 3. New York, American Society of Mechanical Engineers, 1981, p. 2115-2118.

Evolution in design, improvements in economics, and reductions in material and space requirements for the Satellite Power System (SPS) are reviewed. Selection of GaAs solar cells over silicon wafers has been made for reasons of self-annealing and better performance at higher temperatures, in addition to the fact that GaAs cells are the base configuration for multibandgap cells. These cells, when used with 6:1 reflectors, reduce satellite mass by 18%, with a corresponding reduction in satellite area of 75%. The SPS can then be sun-oriented, eliminating tilt control; employment of magnetrons instead of less efficient klystrons eliminates 15% of transmitter weight. New evidence for ionospheric power density tolerance indicates higher permissible power levels, thus allowing larger and fewer (20 instead of 60) satellites delivering 7.57 GW per rectenna site, and capital costs are reduced 40%. Finally, open wire, parabolic rectennas will require 50% less in capital construction costs than former flat designs. The timetable for operational capability is now targeted for the year 2000. M.S.K.

A82-12503#

MICROWAVE POWER TRANSMISSION BY SATELLITES

W. KEYDEL (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Institut fuer Hochfrequenztechnik, Oberpfaffenhofen, West Germany) In: International Scientific Conference on Space, 21st, Rome, Italy, March 25, 26, 1981, Proceedings. Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1981, p. 29-38. refs

The MPTS (microwave power transmission system) is examined with regard to the problems involved, the proposed solutions, the future outlook, and the necessity for further work. The MPTS is analyzed with regard to system considerations, design considerations (power transmission, frequency selection, power generation, the spacetenna, microwave propagation problems, the rectenna, and efficiency), environmental impacts (electromagnetic compatibility and RF interference, and health and ecological effects). It is concluded that the MPTS is feasible, but that further studies are needed to optimize the system with respect to such factors as efficiency and environmental impact. B.J.

A82-12509#

SOLAR POWER SATELLITE SYSTEM ENERGY BALANCE

A. BURATTI (Compagnia Nazionale Satelliti per Telecomunicazione S.p.A., Rome, Italy) In: International Scientific Conference on Space, 21st, Rome, Italy, March 25, 26, 1981, Proceedings. Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1981, p. 99-103. refs

A literature review which concludes that the Shuttle is the basic launch system to LEO, in addition to an IUS, until the year 2000 is presented. Propellant to payload mass ratios are analyzed briefly to show that Shuttle launch can deliver only four tons to GEO, the prime site for the SPS. The energy requirements for propellant and solar array manufacture, and energy consumed in placing an SPS in GEO are calculated to be 5000 kWh/kg, while power delivered by an SPS is given as 700 kWh/kg. The results indicate that an improvement of one to two orders of magnitude is necessary for the SPS to satisfy the requirement that the energy it produces exceeds the power consumed in gaining operational status. M.S.K.

A82-14445

CONTRIBUTIONS OF SPACE REFLECTOR TECHNOLOGY TO FOOD PRODUCTION, LOCAL WEATHER MANIPULATION AND ENERGY SUPPLY, 1985-2020

K. A. EHRLICHE (Space Global Co., La Jolla, CA) British Interplanetary Society, Journal (Space Technology), vol. 34, Dec. 1981, p. 511-518.

The parameters and uses of orbital space reflectors to redirect measured amounts of solar radiation to selected areas of the earth are discussed. Two systems, Lunetta - night illumination, and Soletta solar level irradiation, are considered, noting that solar level reflectance is over a thousand times brighter than moonlight. Optimized orbits, reflective angles, and mirrored surfaces are explored for controlling the image size and location. Soletta applications are envisioned for weather modification, as a source of night time power for electrical generation, and to enhance biomass growth; Lunetta reflectors may be used for urban, polar, and rural illumination, and as a light source for disaster and rescue operations. A prototype Lunetta would have a 1,860 sq km area, with full scale models ranging from 18 to 50 times larger. D.H.K.

A82-14446

A TECHNOLOGICAL APPROACH TOWARDS FUTURE LARGE SOLAR ARRAYS

B. GOERGENS (Space and New Technologies, Wedel, West Germany) British Interplanetary Society, Journal (Space Technology), vol. 34, Dec. 1981, p. 519-526. refs

Developmental strategies for large solar arrays for future space missions are described, noting that enlargements for the near term will be dependent on the ability to interface with the Shuttle. Spacelab missions, currently scheduled for seven days duration, could be extended to 30-90 days if power was available. Higher cell efficiencies, deployable blanket technology, space based mass production of solar cells, and capabilities to handle high voltages are listed as priorities for solar cell development. A comparison is made between technologies for solar and terrestrial solar cells, and mention is made of 100 micron thick cells, 5 x 5 sq cm cells, back field cells, and back reflective surface cells for space applications. A 50 kW array with foldable deployment, high voltage technology, and the success of welded cells are outlined. D.H.K.

A82-14447

FROM HEAVY SATELLITES TO LARGE TELECOMMUNICATIONS PLATFORMS - A CHALLENGING OPPORTUNITY FOR EUROPEAN INDUSTRY

E. VALLERANI and M. PASTA (Aeritalia S.p.A., Naples, Italy) British Interplanetary Society, Journal (Space Technology), vol. 34, Dec. 1981, p. 527-533. European Space Research and Technology Centre

(Contract NSERC-3940/79-NL-AK)

Results of design studies for large telecommunications platforms are reported. Design parameters included Shuttle launch into LEO, fully ground-integrated modules, construction by use of the remote

manipulator system in LEO, and a lifetime of 15 yr. Telephony and TV service modules for use by several countries simultaneously have been designed, along with an interplatform link capacity. A central payload module is intended as a core for the addition of multipurpose modules (solar arrays, batteries, control devices, etc.). A family of derived configurations with growth limits to the number of add-on modules set only by constraints of mass loads balancing is presented, and assembly procedures and diagrams for Shuttle deployment are provided. D.H.K.

A82-15688

FUTURE SPACE ASTRONOMY MISSIONS

J. J. RUSSO and A. N. BUNNER (Perkin-Elmer Corp., Danbury, CT) Technical News, vol. 9, Sept. 1981, p. 39-47. refs

Six space astronomy systems planned for the 1990s are discussed. These include: (1) the Large Area Modular Array of Reflectors (LAMAR), which will conduct searches and flux measurements for X-ray sources, quasars, Seyferts and radio galaxies and employs either Kirkpatrick-Baez or Wolter X-ray telescope optics; (2) the Solar Soft X-ray Telescope Facility (SSXTF), to be deployed aboard Spacelab, which will conduct high-resolution spectroheliogram and line-profile studies over the 1.7-300 Å wavelength range; (3) the Very Large Space Telescope (VLST), with an 8 m primary mirror whose 0.02 arcsec angular resolution at 632 nm is sufficient to resolve H II regions in clusters as much as 100 Mpc away; (4) the Coherent Optical System of Modular Imaging Collectors (COSMIC), whose angular resolution would be equivalent to that of a 36-m-diam telescope; (5) the Large Deployable Reflector (LDR), a multiple-segment telescope operating in the 2-1000 micron range; and (6) the Space Science Platform, incorporating an array of instruments covering the entire electromagnetic spectrum. O.C.

A82-16001

ENGINEERING-DESIGN SOLUTIONS FOR SPACE RADIO-TELESCOPE [RESHENIIA INZHENERNYKH KONSTRUKTSII KOSMICHESKIKH RADIOTELESKOPOV]

A. G. SOKOLOV and A. S. GVAMICHAHA Antenny, no. 29, 1981, p. 3-10. In Russian.

Basic methods for the in-orbit deployment of space radio-telescopes are presented along with methods for the maintenance of telescope shape. Attention is given to the limiting dimensions of automatically unfurlable antennas, materials requirements, basic assembly and unfurling techniques in ground conditions under weightlessness simulation, and the basic design principles of mechanically unfurlable antennas. Some results on the KRT-10 space telescope are presented. B.J.

A82-16002

EXPANDABLE SPACE ANTENNA [KOSMICHESKAIA SKLADNAIA ANTENNA]

A. F. BOGOMOLOV, N. V. BUKAREV, G. N. VAZHENTSEV, I. U. A. KISANOV, N. M. FEIZULLA, and I. F. SOKOLOV Antenny, no. 29, 1981, p. 10-20. In Russian. refs

The development of an expandable truss space antenna is described. The design, weight ratios, and performance potential of this antenna are examined; and results of mechanical and radio-engineering tests of a 5-m-diameter antenna model are presented. B.J.

A82-16005

ANTENNA FOR 'CIRCULAR PERISCOPE' RADIO TELESCOPES [ANTENNA DLIA RADIOTELESKOPOV 'KRUGOVOI PERISKOP']

N. L. KAIDANOVSKII Antenny, no. 29, 1981, p. 32-44. In Russian. refs

The paper examines the possibility of simplifying a variable-profile antenna by excluding the main reflector of radial displacement and azimuthal rotation from the reflecting elements. One inclination axis is preserved, and a secondary reflector is used with a focal line in the form of an evolvent from the horizontal section of the caustic surface of the main reflector, on which the primary feed, a linear array, is located. B.J.

A82-17917*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SPACE PLATFORMS AND METEOROLOGICAL APPLICATIONS

K. L. MITCHELL and G. S. WILSON (NASA, Marshall Space Flight Center, Huntsville, AL) American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 20th, Orlando, FL, Jan. 11-14, 1982, 10 p. refs (AIAA PAPER 82-0387)

The use of Shuttle launched and tended space platforms (SP) for research and earth observations in LEO are examined. SPs will accommodate instruments for extended time periods, requiring a Shuttle visit for maintenance and package exchange once every six months. Designs have included off-the-shelf hardware to reduce cost, and comprise instruments for studies of cosmic rays, solar physics, materials processing, space plasma physics, and environmental observations. Solar cell power arrays are detailed, along with thermal control, data management, and attitude control subsystems. Meteorological applications are discussed in terms of the Lower Atmospheric Research Satellite (LARS), for research into coupling of radiative, chemical, and dynamical processes, interactions between the earth's surface, boundary layer, and troposphere, and dynamic and energetic relationships between lower atmospheric processes. Flight configurations and add-on concepts for the SP to lead to a manned space station are indicated. M.S.K.

A82-17939*# Rockwell International Corp., Downey, Calif.

SPACE OPERATIONS CENTER ORBIT ALTITUDE SELECTION STRATEGY

J. INDRIKIS and H. L. MYERS (Rockwell International Corp., Downey, CA) American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 20th, Orlando, FL, Jan. 11-14, 1982, 9 p.

(Contract NAS9-16153)

(AIAA PAPER 82-0420)

The strategy for the operational altitude selection has to respond to the Space Operation Center's (SOC) maintenance requirements and the logistics demands of the missions to be supported by the SOC. Three orbit strategies are developed: two are constant altitude, and one variable altitude. In order to minimize the effect of atmospheric uncertainty the dynamic altitude method is recommended. In this approach the SOC will operate at the optimum altitude for the prevailing atmospheric conditions and logistics model, provided that mission safety constraints are not violated. Over a typical solar activity cycle this method produces significant savings in the overall logistics cost. (Author)

A82-18644#

SOLAR THERMAL AEROSTAT RESEARCH STATION

E. C. OKRESS and R. K. SOBERMAN (Franklin Institute, Philadelphia, PA) In: Macro-engineering: The rich potential; Proceedings of the Third Symposium, San Francisco, CA, January 6, 1980. New York, American Institute of Aeronautics and Astronautics, 1981, p. 73-96. refs

The solar thermal aerostat research station is a constant-volume sphere of between 1/4 and one mile diameter, which derives both its buoyancy and the energy for the fulfillment of numerous functions from the absorption of radiant solar heat by means of a spectrally-selective, polymeric outer surface. A novel aspect of the aerostat is its lightweight, modular tensegrity structure, which is composed entirely of compression struts and high-tensile strength cable. Equipped with such nighttime energy storage systems as flywheels, stratospheric water electrolysis or compressed air, and by means of such stationkeeping devices as solar-energized compressed air and suppressed electric discharge thrusters, the aerostat would constitute a stratospheric platform for astronomy, earth surveillance, meteorological monitoring, communications relay, and rocket launching. O.C.

01 SYSTEMS

A82-18646#

MULTIPURPOSE MICROWAVE SPACE FACILITY - A MACROENGINEERING PROJECT FOR THE 1990'S

H. L. MAYER (Aerospace Corp., El Segundo, CA) In: Macro-engineering: The rich potential; Proceedings of the Third Symposium, San Francisco, CA, January 6, 1980. New York, American Institute of Aeronautics and Astronautics, 1981, p. 111-130. Research supported by the Aerospace Corp.

With a view to illustrating essential macroengineering principles, consideration is given to the possibility of (1) deploying by the year 2000, communications satellites with multibeam imaging antennas for frequency reuse, and (2), with two long, narrow-beam antennas, the establishment of a navigation grid on the ground. These satellites may be operated as a multipurpose microwave facility which will directly affect existing industries and change established social customs. Attention is given to a macroengineering plan for the multipurpose microwave space facility which reconciles, in addition to engineering features, complex organizational, regulatory, and societal issues. Costs are estimated to be \$10 billion for the satellites and their launching and \$10 million for ground terminals, with a direct influence being exerted on the communications industry that constitutes 5% of the U.S. G.N.P. O.C.

A82-20881

TECHNOLOGICAL APPROACH TOWARDS FUTURE LARGE SOLAR ARRAYS

B. GEORGENS (Telefunken AG, Wedel, West Germany) In: Space in the 1980's and beyond; Proceedings of the Seventeenth European Space Symposium, London, England, June 4-6, 1980. San Diego, CA, American Astronautical Society; Univelt, Inc., 1981, p. 229-250. refs (AAS 80-323)

Three generations of solar arrays are described, the first being characterized by body mounted arrays, the second by rigid paddle arrays, and the third by the direct bonding of solar cells on thin, flexible plastic foils. It is pointed out that the use of solar arrays as power sources could significantly increase the capabilities of the Shuttle and Spacelab. Since the capacity for manufacturing solar cells in Europe has been increased to the required level, attention must now be directed to increasing cell efficiency and decreasing cell thickness toward 100 microns. Detailed development is also required in order to meet the retractability and high-voltage requirements in blanket technology. C.R.

A82-21599

ESA IS PREPARING THE MOST POWERFUL TELECOMMUNICATIONS SATELLITE [L'ESA PREPARE LE PLUS PUISSANT SATELLITE DE 'TELECOM']

P. LANGEREUX Air et Cosmos, vol. 19, Jan. 23, 1982, p. 40-43. In French.

The L-Sat Program is currently being undertaken by ESA with a goal towards providing a series of large telecommunications satellites for direct television broadcasting beginning in 1986. The basic satellite design is that of a multipurpose platform capable of supporting a variety of telecommunications and direct broadcasting missions with a payload mass greater than 500 kg and powers of over 2.5 kW in eclipse and 7 kW in sunlight. The satellite, intended for launch with Ariane 4, consists of a three-axis stabilized platform with a large flexible solar array and an integrated propulsion system. The first experimental satellite of the program, L-Sat 1, will be launched into geosynchronous orbit over 19 deg W carrying payloads for direct television broadcasting in Italy, business services, telecommunications between 20 and 30 GHz, and radio propagation experiments at 12, 20 and 30 GHz. Studies have shown L-Sat type satellites to have a market potential of up to 40 satellites by the year 2000, and have indicated potential missions in direct broadcasting to Canada, and Switzerland and Luxembourg. A.L.W.

A82-22919

THE REMOTE MANIPULATOR SYSTEM SECOND GENERATION SCHEMES

J. R. MCCULLOUGH (Spar Aerospace, Ltd., Remote Manipulator Systems Div., Toronto, Canada) In: Human Factors Society, Annual Meeting, 24th, Los Angeles, CA, October 13-17, 1980, Proceedings. Santa Monica, CA, Human Factors Society, Inc., 1980, p. 209-213.

The operations of the Remote Manipulator System (RMS) on board the Shuttle and design necessities for second generation, expanded function RMSs for future space activities are discussed. The RMS will be used to deploy, reorient, inspect, repair, and activate pallet mounted equipment, map the Shuttle environment, deploy solar arrays, and for construction activities. Future manipulators will comprise large arms over 50 m long for placement of large mass payloads, a modified Shuttle RMS as general purpose tools and the placement of payloads with varying degrees of precision, and small manipulators between 3-10 m length for precise dextrous, or high torque/force applications. The RMS will have increased degrees of freedom, automatic collision avoidance, force sensing and feedback, and special end-purpose effectors, with research going to booms, joints, control systems, and payload interface. M.S.K.

A82-23519#

A DIRECT BROADCAST SATELLITE SERVICE FOR THE UNITED STATES - SYSTEM DESCRIPTION AND TRADE-OFFS

E. R. MARTIN (Satellite Television Corp., Washington, DC) In: Communications Satellite Systems Conference, 9th, San Diego, CA, March 7-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 324-334.

(AIAA 82-0502)

The system described would offer three channels of subscription television to the contiguous U.S. and to the larger populated areas of Alaska and Hawaii. It comprises four operating and two in-orbit space satellites, a large ground complex to uplink and control the satellites, and millions of receive-only terminals at homes, multiple-dwelling units, and cable head-ends. The four operating satellites are to be spaced at 20-deg intervals along the geosynchronous orbital arc, each satellite serving approximately one time zone. One 200-watt spacecraft traveling wave tube amplifier is used for each channel, along with shaped-beam antennas. C.R.

A82-23537*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

AN EXPERIMENTAL GEOSTATIONARY PLATFORM - A STEP TOWARD THE 1990'S

W. T. CAREY, JR. (NASA, Marshall Space Flight Center, Huntsville, AL) In: Communications Satellite Systems Conference, 9th, San Diego, CA, March 7-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 482-488. refs

(AIAA 82-0525)

NASA studies on geostationary platforms are reviewed. Traffic models for geostationary missions through the year 2000 are presented, and the benefits of platforms are shown, as compared with accomplishing the same missions on specialized satellites. These benefits are illustrated by a case study (involving Leasat) demonstrating that substantial cost savings can result because of economies of scale. Technologies in need of development and demonstration are identified, and attention is given to the potential NASA Experimental Geostationary Platform. B.J.

A82-23555#

A MODULAR GEOPLATFORM CONCEPT FOR INTELSAT VII AND OTHER APPLICATIONS

D. E. KOELLE and W. KLEINAU (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) In: Communications Satellite Systems Conference, 9th, San Diego, CA, March 7-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 625-634. (AIAA 82-0549)

The paper describes a new GEO platform design with features of modularity and integrated transfer propulsion, optimized for launch by the Space Shuttle. Technical results concerning the GEO platform and its performance in terms of communication payload and mission lifetime are presented. The reference system design has a total mass of 14.3 Mg (metric tons) including 10.9 Mg transfer propellant mass; the initial mass in GEO is 3.4 Mg allowing for 400-700 kg communication equipment, depending on power level, eclipse capability requirements (batteries), and mission lifetime. As examples, the platform design is shown with a typical Intelsat VII payload, a German national services payload (TVBS and 20/30 GHz data service), and a multinational direct TV-broadcasting payload. B.J.

A82-23557#

DESIGN AND DEVELOPMENT OF THE EUROPEAN LARGE TELECOMMUNICATION SATELLITE /L-SAT/

B. L. HERDAN (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) and B. N. F. EDDLESTON (British Aerospace Public, Ltd., Co., Dynamics Group, Stevenage, Herts., England) In: Communications Satellite Systems Conference, 9th, San Diego, CA, March 7-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 643-652. (AIAA 82-0551)

The program objectives of L-Sat are described, and attention is given to how these objectives are being interpreted in practice. The results of several design tradeoffs in the satellite definition phase are presented along with a description of the selected multipurpose subsystem design and of four communications payloads of the first L-Sat model. Details of the satellite development planning leading to a launch in 1986 are also considered. B.J.

A82-25539

THE SATELLITE COMMUNICATIONS OUTLOOK

B. I. EDELSON and R. D. BRISKMAN (COMSAT General Corp., Washington, DC) British Interplanetary Society, Journal (Space Chronicle), vol. 35, Apr. 1982, p. 147-155. refs

Digital transmission, bandwidth compression, signal regeneration on board communication satellites, and TDMA are some of the techniques being used to improve transmission efficiency. The replacement of large numbers of small single-function satellites by a few multiple-function ones is envisioned as a means of reducing transmission congestion and allowing even smaller earth stations. The Space Shuttle can launch extremely heavy and complex spacecraft into orbit and will play a major role in achieving this goal. Large geostationary platforms carrying a number of different payloads will provide economies of scale but also will present problems regarding the assembly of large structures in space, the interrelation of payloads and institutional concerns. C.D.

A82-25607

ELECTROSTATICALLY-CONTROLLED LARGE-APERTURE REFLECTING SATELLITE ANTENNAS

J. H. LANG and D. H. STAELIN (MIT, Cambridge, MA) In: Conference on Decision and Control, 19th, and Symposium on Adaptive Processes, Albuquerque, NM, December 10-12, 1980, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 991-993. Research supported by the Fannie and John Hertz Foundation refs (Contract DAAG29-78-C-0020)

The major practical and economic limit to the size of antennas in space is the minimum feasible mass per unit reflecting area. To achieve low antenna mass, the mechanical rigidity of the reflector is sacrificed. The achievement of a very precise reflector figure is obtained with the aid of an approach involving a rapid and accurate control of the deflection of many points on the reflector. One method of reflector figure control is based on the employment of electrostatic forces operating between the reflector and a second surface, or command surface. The functions of a reflector figure controller are discussed, and experiments with controllers based upon a three-lowest-mode system model are reported. These experiments demonstrate the feasibility of an electrostatically figured antenna. G.R.

A82-26513

ASTRONOMY IN THE NEXT DECADE

R. A. SCHORN Sky and Telescope, vol. 63, Apr. 1982, p. 339-342.

'Astronomy and Astrophysics for the 1980's', the report of the Astronomy Survey Committee of the National Academy of Sciences, is briefly reviewed. The most important programs recommended by the report are, in order of priority: (1) an advanced X-ray astrophysics facility to be operated as a permanent national observatory in space; (2) a very-long-baseline array of radio telescopes that would attain an angular resolution 100 times greater than that of any image forming telescope operating at any wavelength; (3) a 15-meter-class optical-infrared new-technology telescope; (4) a large deployable reflector in space to observe the region between the infrared and radio bands accessible from the earth's surface. An attempt is made to determine whether such reports make a difference, and the total costs projected in the report are discussed. C.D.

A82-26623* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

A TOWING CONCEPT FOR ORBITAL TRANSFER OF LARGE SPACE STRUCTURES

I. O. MACCONOCHIE, J. J. REHDER, H. L. PRICE, and T. G. CAMPBELL (NASA, Langley Research Center, Hampton, VA) Society of Allied Weight Engineers, Annual Conference, 40th, Dayton, OH, May 4-7, 1981, 36 p. refs (SAWE PAPER 1442)

Many studies are being made to determine the most efficient method for the transfer of large space structures from low earth orbits (LEO) to higher altitudes, principally geosynchronous orbits. In this paper, towing is proposed as a possible means of orbital transfer of large space structures. A potential towing arrangement is identified and some of the systems sized for the transfer of a 2460-ft (750 meter) diameter antenna weighing approximately 154,000 lbs (70 metric tons). A savings of approximately 23 metric tons in propellants and structure resulted from the use of a towing arrangement using six towlines in parallel when compared to the use of a single tug hard mounted to the structure being towed. The towing concept appears practical and affords a means of applying loads using multiple towlines to a wide variety of structures without special adaptors. (Author)

01 SYSTEMS

A82-27135

ADVANCED COMPOSITE SATELLITE EQUIPMENT SUPPORT MODULE STUDY

H. D. THOMPSON, C. H. BIXLER (General Electric Co., Space Div., Philadelphia, PA), and G. B. SMITH (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) In: Fibrous composites in structural design. New York, Plenum Press, 1980, p.161-179. (Contract F33615-77-C-5213)

A description is presented of the results of a study which had been conducted to evaluate the application of advanced composite materials to a satellite main body structure. The primary purpose of this Equipment Support Module (ESM) study has been to evaluate an existing sophisticated satellite structural system for potential composite applications, to assess the effects of composites of system performance and cost, and determine the supporting technology required to integrate composite structures into a satellite system. This effort consisted of design trade studies, materials evaluation, thermal analysis, electrical/survivability evaluation, system payoff analysis, and composite ESM preliminary designs. It was found that composite construction can provide overall weight reductions of 15% to 20% over conventional metal spacecraft structures. Practical designs are feasible using existing composite materials and processes. G.R.

N82-12091*# Rockwell International Corp., Downey, Calif. Space Operations and Satellite Systems Div.

SHUTTLE CONSIDERATIONS FOR THE DESIGN OF LARGE SPACE STRUCTURES

J. A. ROEBUCK, JR. Nov. 1980 411 p refs

(Contract NAS9-15718)

(NASA-CR-160861; SSD-80-0183) Avail: NTIS HC A18/MF A01 CSCL 22A

Shuttle related considerations (constraints and guidelines) are compiled for use by designers of a potential class of large space structures which are transported to orbit and, deployed, fabricated or assembled in space using the Space Shuttle Orbiter. Considerations of all phases of shuttle operations from launch to ground turnaround operations are presented. Design of large space structures includes design of special construction fixtures and support equipment, special stowage cradles or pallets, special checkout maintenance, and monitoring equipment, and planning for packaging into the orbiter of all additional provisions and supplies chargeable to payload. Checklists of design issues, Shuttle capabilities constraints and guidelines, as well as general explanatory material and references to source documents are included. S.L.

N82-12131*# Astro Research Corp., Carpinteria, Calif.

CRITICAL REQUIREMENTS FOR THE DESIGN OF LARGE SPACE STRUCTURES Final Report

J. M. HEDGEPEETH Washington NASA sap HC A03/MF A01 Nov. 1981 50 p refs

(Contract NAS1-15347)

(NASA-CR-3484; ARC-R-1016) Avail: NTIS HC A03/MF A01 CSCL 22B

The design criteria for large space structures are studied. Critical baseline design requirements for general types of structures are identified by a series of rational parametric analyses. Requirements imposed by operational loads, stiffness, and structural-control interactions are addressed along with deformations, precision and member slenderness criteria. Examples of applications of the identified loads and criteria to the design of the spacecraft structures discussed include: truss antenna reflectors, interorbit propulsion loads, and free-flying solar reflectors. S.L.

N82-12539*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SYSTEM PERFORMANCE CONCLUSIONS

G. D. ARNDT In: Workshop on Microwave Power Transmission and Reception p 1-12 1980

Avail: NTIS HC A99/MF A01 CSCL 10A

System sizing is discussed in terms of reduced power levels and antenna diameters smaller than 1 km. The microwave

transmission efficiency for smaller SPS systems was investigated. Startup and shutdown operations were examined with emphasis on solar eclipse effects on the solar arrays. The antennas and subarray mechanical alignments are also discussed. T.M.

N82-14202*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

COMPARATIVE ANALYSES OF SPACE-TO-SPACE CENTRAL POWER STATIONS

P. F. HOLLOWAY and L. B. GARRETT Dec. 1981 49 p refs (NASA-TP-1955; L-14766) Avail: NTIS HC A03/MF A01

CSCL 22B

The technological and economical impact of a large central power station in Earth orbit on the performance and cost of future spacecraft and their orbital transfer systems are examined. It is shown that beaming power to remote users cannot be cost effective if the central power station uses the same power generation system that is readily available for provision of onboard power and microwave transmission and reception of power through space for use in space is not cost competitive with onboard power or propulsion systems. Laser and receivers are required to make central power stations feasible. Remote power transmission for propulsion of orbital transfer vehicles promises major cost benefits. Direct nuclear pumped or solar pumped laser power station concepts are attractive with laser thermal and laser electric propulsion systems. These power stations are also competitive, on a mass and cost basis, with a photovoltaic power station. E.A.K.

N82-14203*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SYSTEM ANALYSIS APPROACH TO DERIVING DESIGN CRITERIA (LOADS) FOR SPACE SHUTTLE AND ITS PAYLOADS. VOLUME 1: GENERAL STATEMENT OF APPROACH

R. S. RYAN, T. BULLOCK, W. B. HOLLAND, D. A. KROSS, and L. A. KIEFLING Dec. 1981 47 p

(NASA-TP-1949; M-358) Avail: NTIS HC A03/MF A01 CSCL 22B

Space shuttle, the most complex transportation system designed to date, illustrates the requirement for an analysis approach that considers all major disciplines simultaneously. Its unique cross coupling and high sensitivity to aerodynamic uncertainties and high performance requirements dictated a less conservative approach than those taken in programs. Analyses performed for the space shuttle and certain payloads, Space Telescope and Spacelab, are used as examples. These illustrate the requirements for system analysis approaches and criteria, including dynamic modeling requirements, test requirements control requirements and the resulting design verification approaches. A survey of the problem, potential approaches available as solutions, implications for future systems, and projected technology development areas are addressed. S.L.

N82-14637*# General Dynamics/Convair, San Diego, Calif.

STUDY OF MULTI-MEGAWATT TECHNOLOGY NEEDS FOR PHOTOVOLTAIC SPACE POWER SYSTEMS, VOLUME 2 Final Report

D. M. PETERSON and R. L. PLEASANT 19 Mar. 1981 285 p refs 2 Vol.

(Contract NAS3-21951)

(NASA-CR-165323-VOL-2; GDC-AST-81-019-VOL-2) Avail: NTIS HC A13/MF A01 CSCL 10A

Possible missions requiring multimegawatt photovoltaic space power systems in the 1990's time frame and power system technology needs associated with these missions are examined. Four specific task areas were considered: (1) missions requiring power in the 1-10 megawatt average power region; (2) alternative power systems and component technologies; (3) technology goals and sensitivity trades and analyses; and (4) technology recommendations. Specific concepts for photovoltaic power approaches considered were: planar arrays, concentrating arrays, hybrid systems using Rankine engines, thermophotovoltaic

approaches; all with various photovoltaic cell component technologies. Various AC/DC power management approaches, and battery, fuel cell, and flywheel energy storage concepts are evaluated. Interactions with the electrical ion engine injection and stationkeeping system are also considered. M.D.K.

N82-15106* # National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SYSTEM ANALYSIS APPROACH TO DERIVING DESIGN CRITERIA (LOADS) FOR SPACE SHUTTLE AND ITS PAYLOADS. VOLUME 2: TYPICAL EXAMPLES

R. S. RYAN, T. BULLOCK, W. B. HOLLAND, D. A. KROSS, and L. A. KIEFLING Dec. 1981 128 p refs
(NASA-TP-1950; M-359-VOL-2) Avail: NTIS HC A07/MF A01 CSCL 22B

The achievement of an optimized design from the system standpoint under the low cost, high risk constraints of the present day environment was analyzed. Space Shuttle illustrates the requirement for an analysis approach that considers all major disciplines (coupling between structures control, propulsion, thermal, aeroelastic, and performance), simultaneously. The Space Shuttle and certain payloads, Space Telescope and Spacelab, are examined. The requirements for system analysis approaches and criteria, including dynamic modeling requirements, test requirements, control requirements, and the resulting design verification approaches are illustrated. A survey of the problem, potential approaches available as solutions, implications for future systems, and projected technology development areas are addressed. E.A.K.

N82-16153* # National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

THE MICROWAVE RADIOMETER SPACECRAFT: A DESIGN STUDY

R. L. WRIGHT, ed. Dec. 1981 239 p refs
(NASA-RP-1079; L-14258) Avail: NTIS HC A11/MF A01 CSCL 22B

A large passive microwave radiometer spacecraft with near all weather capability of monitoring soil moisture for global crop forecasting was designed. The design, emphasizing large space structures technology, characterized the mission hardware at the conceptual level in sufficient detail to identify enabling and pacing technologies. Mission and spacecraft requirements, design and structural concepts, electromagnetic concepts, and control concepts are addressed.

N82-16154* # National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

THE MICROWAVE RADIOMETER SPACECRAFT. A DESIGN STUDY: EXECUTIVE SUMMARY

U. M. LOVELACE *In its* The Microwave Radiometer Spacecraft p 1-14 Dec. 1981 refs
Avail: NTIS HC A11/MF A01 CSCL 22B

A conceptual design was developed for a microwave radiometer spacecraft (MRS) using a large passive reflector, microwave radiometer, and advanced control concepts soil moisture mapping from microwave sensing for global crop forecasting. Mission requirements and tradeoffs were defined, and major subsystems (structural, electromagnetic surface, and attitude control) conceptually designed. An overview of the mission and a summary of the study results are presented. J.M.S.

N82-16155* # National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

MISSION DEFINITION FOR A LARGE-APERTURE MICROWAVE RADIOMETER SPACECRAFT

L. S. KEAFER, JR. *In its* The Microwave Radiometer Spacecraft p 17-32 Dec. 1981 refs
Avail: NTIS HC A11/MF A01 CSCL 22B

An Earth-observation measurements mission is defined for a large-aperture microwave radiometer spacecraft. This mission is defined without regard to any particular spacecraft design concept. Space data application needs, the measurement selection rationale,

and broad spacecraft design requirements and constraints are described. The effects of orbital parameters and image quality requirements on the spacecraft and mission performance are discussed. Over the land the primary measurand is soil moisture; over the coastal zones and the oceans important measurands are salinity, surface temperature, surface winds, oil spill dimensions and ice boundaries; and specific measurement requirements have been selected for each. Near-all-weather operation and good spatial resolution are assured by operating at low microwave frequencies using an extremely large aperture antenna in a low-Earth-orbit contiguous mapping mode. Author

N82-16157* # National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

RADIOMETER DESIGN CONCEPTS FOR LARGE APERTURE MICROWAVE RADIOMETER SPACECRAFT

L. S. KEAFER, JR. *In its* The Microwave Radiometer Spacecraft p 43-49 Dec. 1981 refs
Avail: NTIS HC A11/MF A01 CSCL 22B

Concepts involving active and passive microwave systems for soil-moisture monitoring are discussed. It is shown that the first major development efforts should be directed toward the simpler passive design concepts. Subsequently, five passive design concepts for a microwave radiometer spacecraft are outlined and compared. Some common technology needs, such as large space structures and controls, are shown to exist. Also, some peculiar technology needs are identified, such as complicated phasing networks, dielectric lenses, tapered illumination, and reflector-surface irregularity and distortion control techniques. More detailed studies to address these design concepts and assess the associated technology needs are recommended. J.M.S.

N82-16158* # National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EVOLUTION AND DESIGN CHARACTERISTICS OF THE MICROWAVE RADIOMETER SPACECRAFT

R. L. WRIGHT *In its* The Microwave Radiometer Spacecraft p 51-66 Dec. 1981 refs
Avail: NTIS HC A11/MF A01 CSCL 22B

The evolution of the design of the microwave radiometer spacecraft from conception to preliminary design is described. Alternatives and tradeoff rationale are described, and the configuration and structural design features that were developed and refined during the design processes are presented for the three structural configurations studied (two geodesic trusses and a flexible catenary). Author

N82-16159* # National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

SYSTEMS DESIGN AND ANALYSIS OF THE MICROWAVE RADIOMETER SPACECRAFT

L. B. GARRETT *In its* The Microwave Radiometer Spacecraft p 69-94 Dec. 1981 refs
Avail: NTIS HC A11/MF A01 CSCL 22B

Systems design and analysis data were generated for microwave radiometer spacecraft concept using the Large Advanced Space Systems (LASS) computer aided design and analysis program. Parametric analyses were conducted for perturbations off the nominal-orbital-altitude/antenna-reflector-size and for control/propulsion system options. Optimized spacecraft mass, structural element design, and on-orbit loading data are presented. Propulsion and rigid-body control systems sensitivities to current and advanced technology are established. Spacecraft-induced and environmental effects on antenna performance (surface accuracy, defocus, and boresight off-set) are quantified and structured material frequencies and modal shapes are defined. Author

01 SYSTEMS

N82-16161*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WEIGHT ESTIMATES AND PACKAGING TECHNIQUES FOR THE MICROWAVE RADIOMETER SPACECRAFT

J. K. JENSEN (Kentron International, Inc.) and R. L. WRIGHT *In its* The Microwave Radiometer Spacecraft p 109-125 Dec. 1981 refs

Avail: NTIS HC A11/MF A01 CSCL 22B

Estimates of total spacecraft weight and packaging options were made for three conceptual designs of a microwave radiometer spacecraft. Erectable structures were found to be slightly lighter than deployable structures but could be packaged in one-tenth the volume. The tension rim concept, an unconventional design approach, was found to be the lightest and transportable to orbit in the least number of shuttle flights. Author

N82-17240# Joint Publications Research Service, Arlington, Va.
INSTITUTE DIRECTOR DISCUSSES KRT-10 AND OTHER SPACE ANTENNAS

I. ZAGURA *In its* USSR Rept.: Space, No. 14 (JPRS-79711) p 38-41 22 Dec. 1981 Transl. into ENGLISH from Stroitel'naya Gazeta (Moscow), 12 Apr. 1981 p 3

Avail: NTIS HC A05/MF A01

The KRT-10 radiotelescope space antenna is described. It has a 10 meter umbrella, collapsible support radiators, four megaphones for the 12 centimeter band and a spiral for the 72 centimeter band attached to its body, high frequency radiation meter amplifiers, and a heat regulation system located in the hermetically sealed compartment. The antenna mirror has a reflective surface made from a specially knitted grid bed, woven from 50 micrometer thick metallic fibers. Onboard astrophysical studies using the antenna were conducted for the development of radioastronomical methods in space in two modes: circular rotation of the craft around a transverse axis for mapping of the Milky Way and constant orientation of the craft for observation of a pulsar, together with a 70 meter radiotelescope in the Crimea. Geophysical studies produced high resolution in measurements from space of the radio temperature brightness of the Earth and the world's oceans. Evaluations were conducted of the actual resolution of the antenna and data were taken on the quality of its opening. Signal reception capability was found dependent on the 'mirror' surface. Antennas of large ground radiotelescopes with diameters of approximately 100 meters are being constructed and design of folding antennas with diameters of 30 and 10 meters using the same principle as the 'KRT-10' is being implemented. M.D.K.

N82-17647# Office of Technology Assessment, Washington, D.C.

SOLAR POWER SATELLITES

Aug. 1981 300 p refs

(PB82-108846; OTA-E-144; LC-81-600129) Avail: NTIS HC A13/MF A01 CSCL 10B

The energy potential of the solar power satellite (SPS) was evaluated. The preliminary nature of SPS technology is considered by comparing four alternative SPS systems across a broad range of issues: their technical characteristics, long term energy supply potential, international and military implications, environmental impacts, and institutional effects. The SPS options are also compared to potentially competitive future energy technologies.

GRA

N82-18291*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

DEPLOYABLE PLATFORM SYSTEMS DEVELOPMENT

R. E. JEWELL *In* NASA. Langley Research Center Large Space Systems Technol., 1981 p 219-233 Mar. 1982

Avail: NTIS HC A19/MF A01 CSCL 22B

The long range objective is to achieve technology readiness for one or more deployable platform systems by 1986. Engineering plans and approaches to meet this goal are presented in outline form. L.F.M.

N82-18292*# Martin Marietta Corp., Denver, Colo.

TECHNOLOGICAL NEEDS OF ADVANCED EARTH-OBSERVATION SPACECRAFT

A. L. BROOK *In* NASA. Langley Research Center Large Space Systems Technol., 1981 p 235-240 Mar. 1982

Avail: NTIS HC A19/MF A01 CSCL 22B

An outline of the type of Earth observations needed is presented. The characteristics of a 120 meter by 60 meter microwave radiometer are discussed along with those of supplementary instruments. L.F.M.

N82-18305# Office of Technology Assessment, Washington, D.C.

SOLAR POWER SATELLITES, SUMMARY

Aug. 1981 22 p

(OTA-E-145) Avail: NTIS HC A02/MF A01

The energy potential of the solar power satellite (SPS) was assessed. The preliminary nature of SPS technology was taken into account by comparing four alternative SPS systems across a broad range of issues: their technical characteristics long term energy supply potential, international and military implications, environmental impacts, and institutional effects. The SPS options were also compared to potentially competitive energy technologies in order to identify how choices among them might be made. In addition, a set of Federal research and funding options were developed to address the central questions and uncertainties identified in the report. S.L.

N82-18315*# Martin Marietta Aerospace, Denver, Colo.

PRIMARY PROPULSION/LARGE SPACE SYSTEM INTERACTION STUDY Final Report, Sep. 1979 - Dec. 1980

J. V. COYNER, R. H. DERGANCE, R. I. ROBERTSON, and J. V. WIGGINS Dec. 1981 358 p refs

(Contract NAS3-21955)

(NASA-CR-165277; MCR81-504) Avail: NTIS HC A16/MF A01 CSCL 21H

An interaction study was conducted between propulsion systems and large space structures to determine the effect of low thrust primary propulsion system characteristics on the mass, area, and orbit transfer characteristics of large space systems (LSS). The LSS which were considered would be deployed from the space shuttle orbiter bay in low Earth orbit, then transferred to geosynchronous equatorial orbit by their own propulsion systems. The types of structures studied were the expandable box truss, hoop and column, and wrap radial rib each with various surface mesh densities. The impact of the acceleration forces on system sizing was determined and the effects of single point, multipoint, and transient thrust applications were examined. Orbit transfer strategies were analyzed to determine the required velocity increment, burn time, trip time, and payload capability over a range of final acceleration levels. Variables considered were number of perigee burns, delivered specific impulse, and constant thrust and constant acceleration modes of propulsion. Propulsion stages were sized for four propellant combinations: oxygen/hydrogen, oxygen/methane, oxygen/kerosene, and nitrogen tetroxide/monomethylhydrazine, for pump fed and pressure fed engine systems. Two types of tankage configurations were evaluated, minimum length to maximize available payload volume and maximum performance to maximize available payload mass. S.L.

N82-18583*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

UTILITY AND TECHNOLOGY FOR A SPACE CENTRAL POWER STATION

P. F. HOLLOWAY and L. B. GARRETT *In its* Space Laser Power Transmission System Studies p 85-122 Feb. 1982 refs Presented at the Second AIAA Conf. on Large Space Platforms, Feb. 1981

Avail: NTIS HC A10/MF A01 CSCL 20E

The technological and economical impacts of a large central power station in Earth orbit on the performance and cost of future spacecraft and their orbital-transfer systems are examined. It is

shown that beaming power to remote users cannot be cost-effective if the central power station uses the same power generation system that would be readily available for provision of on-board power. Laser transmitters/receivers to make central power stations feasible are considered. The cost-effectiveness of meeting Earth-orbiting spacecraft electrical demands from a central power station was analyzed, indicating that this application cannot justify the investment required for the central station. Key technology needs which must be met to enable a viable central power station in the future are identified. N.W.

N82-19258*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

JPL ANTENNA TECHNOLOGY DEVELOPMENT

R. E. FREELAND /in NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 429-438 Mar. 1982
 Avail: NTIS HC A21/MF A01 CSCL 22B

Systems-level technology for evolving cost-effective, STS compatible antennas that will be automatically deployed in orbit to perform a variety of missions in the 1985 to 2000 time period is discussed. For large space-based antenna systems, the LSST program has selected deployable antennas for development. The maturity of this class of antenna, demonstrated by the success of smaller size apertures, provides a potential capability for satisfying a significant number of near-term, space-based applications. The offset wrap-rib concept development is the basis of the JPL LSST antenna technology development program. Supporting technology to the antenna concept development include analytical performance prediction, the capability for measuring and evaluating mechanical antenna performance in the intended service environment, and the development of candidate system-level configurations for potential applications utilizing the offset wrap-rib antenna concept.

Author

N82-19259*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

OFFSET WRAP RIB ANTENNA CONCEPT DEVELOPMENT

A. A. WOODS, JR. and N. F. GARCIA /in NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 439-470 Mar. 1982
 Avail: NTIS HC A21/MF A01 CSCL 22B

The demonstration of 50 to 150 m, STS compatible, offset antenna technology readiness is reported. Fabrication of a ground and flight testable partial 55 m reflector section and feed support structure is discussed. Reduction to practice through ground test verification is presently contained in the program. Key objectives for the program include the design of a compatible feed support structure and the fabrication and testing of critical components.

T.M.

N82-19262*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

SUMMARY OF ANTENNA TECHNOLOGY DEVELOPMENT AT THE LANGLEY RESEARCH CENTER

T. G. CAMPBELL /in its Large Space Systems Technol., Pt. 2, 1981 p 491-502 Mar. 1982
 Avail: NTIS HC A21/MF A01 CSCL 22B

Compatible antenna systems for the STS are discussed. Potential applications of the systems include communications, radiometry, and radio astronomy. The technologies discussed are those needed to evaluate, fabricate, package, design, transport, and cost effectively deploy the antenna systems. T.M.

N82-19263*# Harris Corp., Melbourne, Fla.

MAYPOLE (HOOP/COLUMN) CONCEPT DEVELOPMENT PROGRAM

M. R. SULLIVAN /in NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 503-550 Mar. 1982
 Avail: NTIS HC A21/MF A01 CSCL 22B

The program is divided into six tasks: preliminary design and performance; materials development; advanced concepts; economic assessment; demonstration/verification models; and a 15 meter engineering model. All support the main objective of the

program which is the technology development necessary to evaluate, design, manufacture, package, transport and deploy the Hoop/Column reflector by means of a ground-based test program. Progress for each task is reported. T.M.

N82-19276*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ANTENNA SUBSYSTEM REQUIREMENTS

R. E. FREELAND /in NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 707-710 Mar. 1982
 Avail: NTIS HC A21/MF A01 CSCL 22B

An in depth review of the hoop/column and offset wrap rib antenna technology development program was conducted. Additional work that needs to be undertaken to bring concept developments to a system level technology readiness state was identified. L.F.M.

N82-19277*# Boeing Aerospace Co., Seattle, Wash.

CONFIGURATION DEVELOPMENT OF THE LAND MOBILE SATELLITE SYSTEM (LMSS) SPACECRAFT

C. T. GOLDEN, J. A. LACKEY, and E. E. SPEAR /in NASA. Langley Research Center Large Space System Technol., Pt. 2, 1981 p 711-760 Mar. 1982
 Avail: NTIS HC A21/MF A01 CSCL 22B

Configurations for a Land Mobile Satellite System Spacecraft are discussed. It is a preliminary concept of a quad aperture reflector spacecraft capable of relaying radio messages to land mobile units throughout the United States. L.F.M.

N82-19278*# Boeing Aerospace Co., Seattle, Wash.

CONFIGURATION DEVELOPMENT OF THE LAND MOBILE SATELLITE SYSTEM (LMSS) SPACECRAFT: CONCLUSIONS

C. T. GOLDEN, J. A. LACKEY, and E. E. SPEAR /in NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 761-766 Mar. 1982
 Avail: NTIS HC A21/MF A01 CSCL 22B

It is concluded that both the wrap/rib and hoop/column antenna designs are feasible for the Land Mobile Satellite System. Additional configuration design iterations are necessary. L.F.M.

02

ANALYSIS AND DESIGN

Includes interactive techniques, computerized technology design and development programs, dynamic analysis techniques, environmental modeling, thermal modeling, and math modeling.

A82-10121#

INTEGRATED DESIGN SYSTEM FOR LARGE SPACE SYSTEMS

C. E. FARRELL (Martin Marietta Aerospace, Denver, CO) In: Computers in Aerospace Conference, 3rd, San Diego, CA, October 26-28, 1981, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1981, p. 331-335. (AIAA 81-2167)

A description is provided of the functional aspects of a computer aided engineering tool that is being implemented to provide the capability of performing interactive, iterative, integrated analyses of Large Space Systems (LSS). Attention is given to analytical software tools for predicting and evaluating performance, aspects of data management, the data base architecture, the executive software, and aspects of interactive graphics capability. It is pointed out that LSS have been proposed for several types of large antenna missions. Typical antenna diameters are in the range from 20 to 100 meters with operating frequencies from 0.8 to 30 gigahertz.

G.R.

02 ANALYSIS AND DESIGN

A82-20625

TOWARD THE IMPROVED USE OF THE GEOSTATIONARY SATELLITE ORBIT THROUGH BETTER SYSTEM PERFORMANCE

R. G. AMERO (Department of Communications, International Telecommunications Branch, Ottawa, Canada) and D. JUNG (Spar Aerospace, Ltd., Sainte Anne de Bellevue, Quebec, Canada) In: NTC '80; National Telecommunications Conference, Houston, TX, November 30-December 4, 1980, Conference Record. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 33.2.1-33.2.5. refs

This paper examines the system performance of a satellite network and how the choice of some system parameters could improve the efficient use of the geostationary satellite orbit. A number of recent events make it imperative to ensure that a maximum number of satellite networks will be accommodated; of particular note is the scheduling of 84/85 Space WARC. Intelsat IVA and V system parameters are used to illustrate the effect of carrier parameters on the efficient use of the orbit. Several additional means of improving orbit/spectrum efficiency are examined. The paper points out the need for developing adequate CCIR recommendations in these areas, which can then be used as the basis for new ITU Radio Regulations. (Author)

A82-20642*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

COST AND SIZING SENSITIVITIES FOR THE SOLAR POWER SATELLITE

L. MONFORD, G. D. ARNDT, and J. W. SEYL (NASA, Johnson Space Center, Houston, TX) In: NTC '80; National Telecommunications Conference, Houston, TX, November 30-December 4, 1980, Conference Record. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 48.3.1-48.3.5.

A summary is provided of the characteristics and error parameters of the reference microwave transmission system for the solar power satellite (SPS). The relative importance of electrical and mechanical tolerances upon scattered microwave power and electrical costs is investigated. It is found that small increases in efficiency and/or reduction of losses (less than one percent) can improve the revenue from a single satellite over its 30-year lifetime by several hundred million dollars. Attention is given to a system definition, cost sensitivities for the reference system, the klystron dc-RF conversion efficiency, the transmitting antenna, the rectenna collection efficiency, system sizing tradeoffs, a cost analysis, and multiple antennas. G.R.

A82-21391* Illinois Inst. of Tech., Chicago.

CALCULATION OF SENSITIVITY DERIVATIVES IN THERMAL PROBLEMS BY FINITE DIFFERENCES

R. T. HAFTKA and D. S. MALKUS (Illinois Institute of Technology, Chicago, IL) International Journal for Numerical Methods in Engineering, vol. 17, Dec. 1981, p. 1811-1821. refs (Contract NSG-1266)

The optimum design of a structure subject to temperature constraints is considered. When mathematical optimization techniques are used, derivatives of the temperature constraints with respect to the design variables are usually required. In the case of large aerospace structures, such as the Space Shuttle, the computation of these derivatives can become prohibitively expensive. Analytical methods and a finite difference approach have been considered in studies conducted to improve the efficiency of the calculation of the derivatives. The present investigation explores two possibilities for enhancing the effectiveness of the finite difference approach. One procedure involves the simultaneous solution of temperatures and derivatives. The second procedure makes use of the optimum selection of the magnitude of the perturbations of the design variables to achieve maximum accuracy. G.R.

A82-23477#

SHUTTLE-TO-GEOSTATIONARY ORBITAL TRANSFER BY MID-LEVEL THRUST

G. PORCELLI (International Telecommunications Satellite Organization, Washington, DC) In: Communications Satellite Systems Conference, 9th, San Diego, CA, March 7-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 1-10. refs (AIAA 82-0439)

This paper describes a method for determining the trajectory and the related maneuver requirements (initial conditions, steering angles, and time sequence of events) for transferring a space vehicle, by means of a two-burn mid-level thrust propulsion, from low, inclined, parking orbit to geostationary orbit. The method has been applied to a number of constant thrust and constant acceleration transfers, and the results are displayed in parametric curves showing the trade-offs (efficiency, transfer time) of this approach versus the high thrust Hohmann transfer. The sensitivity of propellant requirement to thrust direction is also investigated.

(Author)

A82-24586*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

SOME ASPECTS OF ALGORITHM PERFORMANCE AND MODELING IN TRANSIENT THERMAL ANALYSIS OF STRUCTURES

H. M. ADELMAN, J. C. ROBINSON (NASA, Langley Research Center, Hampton, VA), and R. T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg, VA) American Society of Mechanical Engineers, Winter Annual Meeting, Washington, DC, Nov. 15-20, 1981, 8 p. refs

(ASME PAPER 81-WA/HT-4) MEMBERS, \$2.00; NONMEMBERS, \$4.00

The status of an effort to increase the efficiency of calculating transient temperature fields in complex aerospace vehicle structures is described. The advantages and disadvantages of explicit and implicit algorithms are discussed. A promising set of implicit algorithms with variable time steps, known as the GEAR package is described. Four test problems, used for evaluating and comparing various algorithms, have been selected and finite-element models of the configurations are described. These problems include a Space Shuttle frame component, an insulated cylinder, a metallic panel for a thermal protection system, and a model of the Space Shuttle Orbiter wing. Results generally indicate a preference for implicit over explicit algorithms for solution of transient structural heat transfer problems when the governing equations are 'stiff' (typical of many practical problems such as insulated metal structures). (Author)

N82-10066*# Scientific Analysts and Consultants, Inc., Rockville, Md.

A GENERAL METHOD FOR COMPUTING THE TOTAL SOLAR RADIATION FORCE ON COMPLEX SPACECRAFT STRUCTURES

F. K. CHAN In NASA. Goddard Space Flight Center Sixth Ann. Flight Mech./Estimation Theory Symp. 12 p Oct. 1981 refs

Avail: NTIS HC A13/MF A01 CSCL 03B

The method circumvents many of the existing difficulties in computational logic presently encountered in the direct analytical or numerical evaluation of the appropriate surface integral. It may be applied to complex spacecraft structures for computing the total force arising from either specular or diffuse reflection or even from non-Lambertian reflection and re-radiation. T.M.

N82-13159 Stanford Univ., Calif.

TECHNICAL BASIS FOR EFFICIENT MANAGEMENT OF GEOSTATIONARY SATELLITE ORBIT/SPECTRUM Ph.D. Thesis

M. K. SAMARKANDY 1981 311 p

Avail: Univ. Microfilms Order No. 8124146

The technical factors for efficient and effective management of the orbit and radio frequency spectrum is established. Concepts

of available isolation and required isolation between interfering satellites are introduced to solve inhomogeneous orbit congestion problems that arise between broadcasting and/or fixed satellite systems using different Earth station sizes and transmitting different modulating signals. Methods for reducing this interference are described that employ frequency coordination, polarization isolation, satellite beams separation, and modulation selection.

Dissert. Abstr.

N82-14128# Pisa Univ. (Italy). Gruppo di Meccanica Spaziale. **MODELING OF ORBITAL PERTURBATIONS DUE TO RADIATION PRESSURE FOR HIGH EARTH SATELLITES** L. ANSELMO, P. FARINELLA, A. MILANI, and A. M. NOBILI *In* ESA Spacecraft Flight Dyn. p 47-52 Aug. 1981 refs
 Avail: NTIS HC A22/MF A01; ESA, Paris FF 160 Member States, AU, CN and NO (+20% others)

By general perturbations techniques, the orbital effects of radiation pressure in the semimajor axis and in longitude are computed and divided into long and short periodic ones. Long periodic effects are excluded for constant attitude spacecraft. Even for satellites with an Earth pointing antenna, for low inclination and eccentricity and for good antenna pointing, long periodic perturbations in the semimajor axis are small. However, there are longitude perturbations of secular character. The perturbations on the orbit of the SIRIO 2 satellite are computed as an example. An accurate orbit determination is possible for high, e.g., geosynchronous, satellites if orbit and attitude are carefully chosen. Author (ESA)

N82-14256*# TRW Defense and Space Systems Group, Redondo Beach, Calif.

NASCAP CHARGING CALCULATIONS FOR A SYNCHRONOUS ORBIT SATELLITE

N. L. SANDERS and G. T. INOUE *In* NASA. Lewis Research Center Spacecraft Charging Technol., 1980 p 684-708 Oct. 1980 refs

Avail: NTIS HC A99/MF A01 CSCL 22B

The use of the NASA Charging Analyzer Program (NASCAP) for the computation of spacecraft charge up in the energetic plasma environment of geosynchronous orbits is described. Spacecraft modelling, materials parameters, and NASCAP charging analyses are described. The synchronous orbit plasma environment used in the stress analysis employs a two Maxwellian energy distribution to determine the fluxes. Several NASCAP runs performed to determine the location and magnitude of environmentally induced voltage stresses are analyzed. J.D.H.

N82-14263*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

USE OF CHARGING CONTROL GUIDELINES FOR GEOSYNCHRONOUS SATELLITE DESIGN STUDIES

N. J. STEVES *In its* Spacecraft Charging Technol., 1980 p 789-801 Oct. 1980 refs

Avail: NTIS HC A99/MF A01 CSCL 22B

Several of the principle guidelines from the Spacecraft Charging Design Guidelines Handbook are presented with illustrative examples. Use of the geomagnetic substorm specification to qualify satellite designs, the evaluation of satellite designs by using analytical modelling techniques, the use of selected materials and coatings to minimize charging, the tying of all conducting elements to a common ground, and the use of electrical filtering to protect circuits from discharge induced upsets are discussed. Discharge criteria and SCATHA data are excluded. J.D.H.

N82-14274*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

THREE DIMENSIONAL SPACE CHARGE MODEL FOR LARGE HIGH VOLTAGE SATELLITES

D. COOKS (Rice Univ.), L. W. PARKER (Parker (Lee W.), Inc.), and J. E. MCCOY *In* NASA. Lewis Research Center Spacecraft Charging Technol., 1980 p 957-978 Oct. 1980 refs
 (Contract NAS9-16206)

Avail: NTIS HC A99/MF A01 CSCL 22B

High power solar arrays for satellite power systems with dimensions of kilometers, and with tens of kilovolts distributed over their surface face many plasma interaction problems that must be properly anticipated. In most cases, the effects cannot be adequately modeled without detailed knowledge of the plasma sheath structure and space charge effects. Two computer programs were developed to provide fully self consistent plasma sheath models in three dimensions as a result of efforts to model the experimental plasma sheath studies at NASA/JSC. Preliminary results indicate that for the conditions considered, the Child-Langmuir diode theory can provide a useful estimate of the plasma sheath thickness. The limitations of this conclusion are discussed. Some of the models presented exhibit the strong ion focusing observed in the JSC experiments. A.R.H.

N82-14276*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

INTERACTIVE DESIGN AND ANALYSIS OF FUTURE LARGE SPACECRAFT CONCEPTS

L. B. GARRETT Dec. 1981 32 p refs Presented at the 16th AIAA Thermophys. Conf., Palo Alto, Calif., 23-25 Jun. 1981

(NASA-TP-1937; L-14739) Avail: NTIS HC A03/MF A01

CSCL 22B

An interactive computer aided design program used to perform systems level design and analysis of large spacecraft concepts is presented. Emphasis is on rapid design, analysis of integrated spacecraft, and automatic spacecraft modeling for lattice structures. Capabilities and performance of multidiscipline applications modules, the executive and data management software, and graphics display features are reviewed. A single user at an interactive terminal create, design, analyze, and conduct parametric studies of Earth orbiting spacecraft with relative ease. Data generated in the design, analysis, and performance evaluation of an Earth-orbiting large diameter antenna satellite are used to illustrate current capabilities. Computer run time statistics for the individual modules quantify the speed at which modeling, analysis, and design evaluation of integrated spacecraft concepts is accomplished in a user interactive computing environment. E.A.K.

N82-17256*# Martin Marietta Aerospace, Denver, Colo.

ADVANCED SPACE SYSTEM ANALYSIS SOFTWARE. TECHNICAL, USER, AND PROGRAMMER GUIDE Final Report, Sep. 1980 - Sep. 1981

C. E. FARRELL and H. F. ZIMBELMAN Sep. 1981 168 p refs

(Contract NAS1-16447)

(NASA-CR-165798; MCR-81-1334) Avail: NTIS HC A08/MF A01 CSCL 22B

The LASS computer program provides a tool for interactive preliminary and conceptual design of LSS. Eight program modules were developed, including four automated model geometry generators, an associated mass properties module, an appendage synthesizer module, an rf analysis module, and an orbital transfer analysis module. The existing rigid body controls analysis module was modified to permit analysis of effects of solar pressure on orbital performance. A description of each module, user instructions, and programmer information are included. T.M.

02 ANALYSIS AND DESIGN

N82-18281*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.

FINITE ELEMENT THERMAL-STRUCTURAL MODELING OF ORBITING TRUSS STRUCTURES

E. A. THORNTON, J. MAHANEY, and P. DECHAUMPHAI /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 93-108 Mar. 1982 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

A description of an integrated finite element (FE) thermal-structural approach for accurate and efficient modeling of large space structures is presented. A geometric model with a common discretization for all analyses is employed. It uses improved thermal elements and the results from the thermal analysis directly in the structural analysis without any intervening data processing. The differences between the conventional FE approach as implemented in large programs and an integrated FE approach currently under development are described. Considerations for thermal modeling of truss members is discussed and three thermal truss finite elements are presented. The performance of these elements was evaluated for typical truss members neglecting joint effects. A simple truss with metallic joints and composite members was studied to evaluate the effectiveness of the approach for realistic truss designs. A study of the effects of aluminum joints on the thermal deformations of a simple, plane truss with composite members showed that joint effects may be significant. Further study is needed to assess the role of joint effects on the deformation of large trusses. M.D.K.

N82-18285*# Boeing Aerospace Co., Seattle, Wash.

IAC LEVEL 'O' PROGRAM DEVELOPMENT

R. G. VOS /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 145-157 Mar. 1982 (Contract NAS5-25767)

Avail: NTIS HC A19/MF A01 CSCL 22B

The current status of the IAC development activity is summarized. The listed prototype software and documentation was delivered, and details were planned for development of the level 1 operational system. The planned end product IAC is required to support LSST design analysis and performance evaluation, with emphasis on the coupling of required technical disciplines. The long term IAC effectively provides two distinct features: a specific set of analysis modules (thermal, structural, controls, antenna radiation performance and instrument optical performance) that will function together with the IAC supporting software in an integrated and user friendly manner; and a general framework whereby new analysis modules can readily be incorporated into IAC or be allowed to communicate with it. T.M.

N82-18286*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

IAC CONTROL SYSTEM ANALYSIS DEVELOPMENT

H. P. FRISCH /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 159-167 Mar. 1982 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

The MultiOptimal Differential Equation Language (MODEL) is described. It provides a means for generating numerical solutions to systems of differential equations using a digital computer. The notation of this language is similar to that usually used in describing physical systems by differential equations. Thus, the learning process is simplified, programming becomes easier, and debugging is more readily accomplished. Programs written in the MultiOptimal Differential Equation Language are machine translated into FORTRAN 4 code which is optimal in several respects. The interactive version of MODEL makes use of interactive system routines so that the user may observe the solution as it is being generated and interact with the program in a manner similar to that associated with analog simulation. The DISCOS-Control version of the MODEL simulation language is used to describe the control system for a plant which is modelled by the DISCOS program. DISCOS plant variables may be referenced in the control system description and all the sensor signals, coupling torques, momentum devices and external loads are automatically linked to the DISCOS plant model. T.M.

N82-18287*# Martin Marietta Corp., Denver, Colo.

LARGE ADVANCED SPACE SYSTEMS (LASS) COMPUTER-AIDED DESIGN PROGRAM ADDITIONS

C. E. FARRELL /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 169-177 Mar. 1982 (Contract NAS1-1644)

Avail: NTIS HC A19/MF A01 CSCL 22B

The LSS preliminary and conceptual design requires extensive iterative analysis because of the effects of structural, thermal, and control intercoupling. A computer aided design program that will permit integrating and interfacing of required large space system (LSS) analyses is discussed. The primary objective of this program is the implementation of modeling techniques and analysis algorithms that permit interactive design and tradeoff studies of LSS concepts. Eight software modules were added to the program. The existing rigid body controls module was modified to include solar pressure effects. The new model generator modules and appendage synthesizer module are integrated (interfaced) to permit interactive definition and generation of LSS concepts. The mass properties module permits interactive specification of discrete masses and their locations. The other modules permit interactive analysis of orbital transfer requirements, antenna primary beam n, and attitude control requirements. T.M.

N82-18311*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN PRACTICES FOR CONTROLLING SPACECRAFT CHARGING INTERACTIONS

N. J. STEVENS 1982 21 p refs Presented at the 20th Aerospace Sci. Meeting, Orlando, Fla., 11-14 Jan. 1982; sponsored by AIAA

(NASA-TM-82781; E-1112) Avail: NTIS HC A02/MF A01 CSCL 22B

A design guidelines handbook prepared to provide criteria for assessing and minimizing spacecraft charging interactions is described. An evaluation philosophy of analyzing specific satellite designs in a substorm environment specification with NASCAP is proposed. Criteria for possible discharges are given and a technique for computing the discharge transients is outlined. The charging of a three axis stabilized satellite is examined to illustrate the philosophy. Possible discharge locations are found and transients computed. The effect of changing selected surface coatings is evaluated and found to substantially reduce charging levels. J.M.S.

03

STRUCTURAL CONCEPTS AND ANALYSIS

Includes erectable structures (joints, struts, and columns), deployable platforms and booms, solar sail, deployable reflectors, space fabrication techniques, protrusion processing, structural analysis and design techniques, and thermal control systems.

A82-10916#

ON PALLET MOUNTED DEPLOYABLE RADIATOR SYSTEMS

N. NERVEGNA and G. L. ZAROTTI (Torino, Politecnico, Turin, Italy) American Society of Mechanical Engineers, Intersociety Conference on Environmental Systems, San Francisco, CA, July 13-15, 1981, 16 p. Consiglio Nazionale delle Ricerche (Contract CNR-SAS-80,0171)

(ASME PAPER 81-ENAS-29) MEMBERS, \$2.00; NONMEMBERS, \$4.00.

An analysis is reported for the evaluation of characteristics, performance and mass of a multipanel deployable space radiator for a set of fluid-mechanic and environmental conditions. The analysis takes into account the pressure drop in the radiator tubes and headers, their meteoroid protection, the axial and radial temperature gradients in each modular panel. This heat-rejection device is envisaged as a potential 'on pallet' mounted component

in future Space Shuttle missions. Two candidate working fluids, typically Freon R21 and E1 have been considered and their relative performance discussed. Basic aspects of the analysis, equations and procedures are presented and some of the thermal characteristics are demonstrated. A peculiar feature of the methodology rests on a statistical approach based on samples of random vectors built up with key-variables. Influences on results of this nondeterministic approach are also presented. (Author)

A82-10917#
THERMAL CONTROL SUBSYSTEM DEFINITION FOR SCIENCE AND APPLICATIONS PLATFORM

W. G. NELSON (McDonnell Douglas Astronautics Co., Huntington Beach, CA) American Society of Mechanical Engineers, Intersociety Conference on Environmental Systems, San Francisco, CA, July 13-15, 1981, 9 p. refs
 (ASME PAPER 81-ENAS-30) MEMBERS, \$2.00; NONMEMBERS, \$4.00

The Conceptual Design Study of a Science and Applications Space Platform (SASP) defined concepts for a multipayload, free-flying platform attached to a Power System and serviced by the Space Shuttle. The Platforms were designed to accommodate large payloads, and to allow for simultaneous multidirectional payload viewing. This paper addresses the Thermal Control Subsystem (TCS) selection and design which provides cooling for attached payloads and Platform equipment. The various trades are presented which led to the selected design. A major trade compared a centralized radiator concept with a pallet radiator concept. Several minor trades supported this major trade and these included comparisons of loop arrangements, payload interface options, and radiator arrangements. After selection of the TCS concept, studies were performed to optimize the radiator design based on nine separate parameters. Off-design point and peak performance capability were also evaluated. (Author)

A82-10930*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
THERMAL VACUUM TESTING OF FLEXIBLE RADIATOR SYSTEMS

G. RANKIN (NASA, Johnson Space Center, Houston, TX) and D. BENKO (Vought Corp., Dallas, TX) American Society of Mechanical Engineers, Intersociety Conference on Environmental Systems, San Francisco, CA, July 13-15, 1981, 11 p. refs
 (ASME PAPER 81-ENAS-46) MEMBERS, \$2.00; NONMEMBERS, \$4.00

Flexible fin radiators are being developed to meet spacecraft requirements of light weight, compact launch volume, modular growth, reusability, and the capability of an on-orbit deployment and retraction. Two prototype versions of deployable/retractable, flexible fin-space radiators (soft and hard tube) were tested simultaneously under thermal vacuum conditions. A map of the heat rejection performance of each radiator panel under various environmental conditions is given. The soft tube radiator deployment system demonstrated minimal gas pressure and was capable of maintaining partial deployment; temperature control was achieved by varying the deployment length. The radiator could be recovered after an inadvertent freezing of the coolant in the Teflon tube. The hard tube radiator deployment mechanism performed adequately throughout the testing, but did exhibit some undesirable performance characteristics. The hard tube radiator pressure drop was higher than expected, but was not affected by the length of deployment. The radiator operated at less than full deployment, and the manifolds were found to have a significant effect on heat rejection. At low-load conditions, the hard tube radiator appeared to bypass its deployed area. J.F.

A82-10982#
MINIMUM-MASS TRUSS STRUCTURES WITH CONSTRAINTS ON FUNDAMENTAL NATURAL FREQUENCY

L. BELLAGAMBA (Textron, Inc., Hydraulic Research Div., Irvine, CA) and T. Y. YANG (Purdue University, West Lafayette, IN) AIAA Journal, vol. 19, Nov. 1981, p. 1452-1458. refs

A technique for constrained parameter optimization is presented and applied to the minimum-mass design of truss structures. The procedure employs an exterior penalty function to transform the constrained objective function into an unconstrained index of performance which is minimized by the Gauss method. The Gauss method recasts the minimization problem to one of solving simultaneous linear equations with the variation of the parameters as the unknown. The technique is first applied to several test problems, demonstrating its relative efficiency and accuracy. Next, the standard test problems are altered to introduce local buckling constraints and new designs are obtained. It is shown these designs also satisfy global stability. Finally, static thermal loads are introduced, and an equality constraint is imposed on the fundamental natural frequency of each structure. The natural frequency analysis uses a four-degree-of-freedom axial-force bar element. (Author)

A82-11242
NONLINEAR THREE-DIMENSIONAL ANALYSIS OF PREBUCKLED DOMES

A. M. WOLDE-TINSAE (Iowa State University of Science and Technology, Ames, IA) and J. V. HUDDLESTON (New York, State University, Buffalo, NY) Computers and Structures, vol. 14, no. 3-4, 1981, p. 215-224. Research supported by the State University of New York and Iowa State University of Science and Technology. refs

A method of nonlinear analysis for a special type of self-erecting dome (the prebuckled dome) made by elastically buckling an array of wide, shallow members into a radial pattern of intersecting prestressed arches is presented. The nonlinear three-dimensional analysis of the prebuckled dome is conducted by uncoupling the dome into individual prebuckled arches. The individual arches are studied by formulating the problem as a two-point nonlinear boundary value problem. The system of arches is then reassembled to form the skeleton of the prebuckled dome by enforcing equilibrium and compatibility at the crown of the dome. (Author)

A82-12405
FLEXIBLE SHELLS

E. L. AXELRAD (Aachen, Rheinisch-Westfaelische Technische Hochschule, Aachen, West Germany) In: Theoretical and applied mechanics; Proceedings of the Fifteenth International Congress, Toronto, Canada, August 17-23, 1980. Amsterdam, North-Holland Publishing Co., 1980, p. 45-56. refs

A unified analysis of flexible shells is presented which is based on the recognition of the fundamental features of the stressed state that assure the flexibility. Basic systems of flexible shell theory are derived in Reissner and Vlasov versions. The theory is illustrated by several applications, and a hypothesis simplifying the buckling analysis is discussed. A review of Saint-Venant semiinverse solutions is also presented. P.T.H.

A82-12535* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TEST PROGRESS ON THE ELECTROSTATIC MEMBRANE REFLECTOR

J. W. GOSLEE (NASA, Langley Research Center, Hampton, VA) and D. J. MIHORA (General Research Corp., Santa Barbara, CA) In: The year of the Shuttle; Proceedings of the Eighteenth Space Congress, Cocoa Beach, FL, April 29-May 1, 1981. Cocoa Beach, FL, Canaveral Council of Technical Societies, 1981, p. 4-13 to 4-39.

NASA is currently developing a low mass antenna which derives its reflector surface quality from the application of electrostatic forces to form a thin membrane into the desired concave reflector surface. The shuttle-deployed antenna would have a diameter of 100 m and an RMS surface smoothness of 10 to 1 mm for operation

03 STRUCTURAL CONCEPTS AND ANALYSIS

at 1 to 10 GHz. Surface quality measurements have been made on a highly deformable elastic membrane, pressurized by electrostatic forces. Included are the effects of the perimeter boundary, splicing of the membrane, the long-scale smoothness of commercial membranes, and the spatial controllability of the membrane using voltage adjustments to alter the electrostatic forces. The electrostatic membrane was found to operate well in an open-loop sense, showing a high degree of position stability and negligible power consumption in dry air. Visco-electric creep was not evident, but the polymer membrane did expand and contract considerably due to its hygroscopic expansion coefficient. A residual roughness of about 0.75 mm existed with the polymer used in these tests; this error is attributed to seams and membrane anisotropy where the material is stiffer in one direction. J.F.

A82-13276

CALCULATION OF THE ELASTIC DEFORMATIONS OF THE REVOLUTION MEMBRANES

P. CASAL (Aix-Marseille I, Universite, Marseille, France), C. FAYARD, and B. AUTHIER (CNRS, Laboratoire d'Astronomie Spatiale, Marseille, France) *Applied Optics*, vol. 20, June 1, 1981, p. 1983-1989. refs

It is noted that a number of applications, both on the ground and in space, are envisaged for large, light parabolic reflectors which are compact when folded. A differential method is used to calculate the deformed meridian line and the creased zone of an elastic inflatable revolution membrane. It is possible to calculate the original meridian line which, under a given pressure, transforms into a selected meridian line, in this case parabolic. The theory is confirmed through the deformation measurements of a cap in 36-micron thick polyester film cut out of a sphere 4 m in diameter. C.R.

A82-18255

LARGE SCALE STRUCTURAL OPTIMISATION

A. RAJARAMAN (Council of Scientific and Industrial Research, Structural Engineering Research Centre, Madras, India) In: *Numerical methods for engineering*; Proceedings of the Second International Congress, Paris, France, December 1-5, 1980. Volume 2. Paris, Dunod, 1980, p. 887-897. refs

Developments in large-scale structural optimization are traced, with detailed discussions of the difficulties and drawbacks in formulations relying on finite elements, different algorithms and computer usage. Specific studies of the use of approximation concepts on typical structures are then presented with special emphasis on (1) variable linking, (2) basis reduction in the optimization phase, (3) basis reduction in the analysis and design phase, and (4) optimality criteria. The results indicate time requirements on the basis of analysis optimization, and the size of the problems handled. Conclusions are drawn from the results of a study of a 25-bar truss and geodesic dome. C.R.

A82-21183

A COMPACTNESS PROPERTY ROLE IN THE SOLUTION OF A PROBLEM OF EXTERIOR COUPLING [SUR UNE PROPRIETE DE COMPACTITE POUR LA RESOLUTION D'UN PROBLEME DE COUPLAGE EXTERIEUR]

J. ANGELINI (ONERA, Chatillon-sous-Bagneux, Hauts-de-Seine, France), J. BOUJOT (Orleans, Universite, Orleans, France), and M. DURAND (Aix-Marseille I, Universite, Marseille, France) *ONERA, TP no. 1981-137*, 1981. (p. 327-330) 4 p. In French. (ONERA, TP NO. 1981-137)

An analytical model for the behavior of a flexible shell imbedded in an exterior, compressible fluid is presented. The shell is modeled as an open space, bounded by the fluid and subjected to harmonic excitations normal to its surface. The potential field of fluid displacement and the vector displacement of the shell are the unknowns, which are defined by a series of partial differential equations, and a solution is found from a series of coupled integral equations. A spectral problem results, solvable by proof of the compactness of the reciprocals of the operators. The model is amenable to numerical treatments. M.S.K.

A82-27416

DEVELOPMENT OF ADVANCED COMPOSITE SPACECRAFT ANTENNA REFLECTOR STRUCTURES

R. A. STONIER (Ford Aerospace and Communications Corp., Western Development Laboratories, Palo Alto, CA) In: *Technology transfer*; Proceedings of the Thirteenth National Technical Conference, Mount Pocono, PA, October 13-15, 1981. Azusa, CA, Society for the Advancement of Material and Process Engineering, 1981, p. 203-217. refs

Graphite and Kevlar composites are ideal for spacecraft antennas because of their lightness, near-zero thermal coefficient of expansion, high specific strength and specific modulus properties. Graphite is wound as a skin over an aluminum honeycomb or Kevlar core in a stiffened laminate shell, unstiffened 'full depth' sandwich shell, or stiffened thin sandwich shell. The antenna reflector structure of the Viking Mars Orbiter, which was an unstiffened sandwich shell with graphite epoxy faceskins, successfully demonstrated that such a structure was cost competitive with metallic designs. The Voyager antenna primary reflector shell had thick graphite epoxy skins over an aluminum honeycomb core, while the secondary reflector contained a frequency selective surface of Kevlar epoxy faceskins with Nomex honeycomb core. All structural parts of the Japan Communications Satellite antenna used graphite or Kevlar epoxy materials. The Intelsat V reflector structures are thin honeycomb sandwich shells with a stiffening rib structure. India's Insat-I system has offset-fed graphite composite antennas. C.D.

N82-10079*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

MSFC EVALUATION OF THE SPACE FABRICATION DEMONSTRATION SYSTEM (BEAM BUILDER)

E. O. ADAMS and C. N. IRVINE Sep. 1981 52 p refs (Contract NAS8-32472)

(NASA-TM-82440) Avail: NTIS HC A04/MF A01 CSCL 22A

The beam builder, designed and manufactured as a ground demonstration model, is a precursor to a machine for use in the space environment, transportable by the space shuttle. The beam builder has the capability to automatically fabricate triangular truss beams in low Earth orbit with a highly reliable machine that requires a minimum of in-space maintenance and repair. A performance assessment of the beam builder, which was fabricated from commercial hardware is given. J.M.S.

N82-10402*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

MODULAR ANTENNA DESIGN STUDY Final Report

J. W. RIBBLE Sep. 1981 202 p refs

(Contract NAS1-14887)

(NASA-CR-3316; LMSC-D714622) Avail: NTIS HC A10/MF A01 CSCL 13I

The mechanical design of a modular antenna concept was developed sufficiently to allow manufacture of a working demonstration model of a module, to predict mass properties, and to make performance estimates for antenna reflectors composed of these modules. The primary features of this concept are: (1) each module is an autonomous structural element which can be attached to adjacent modules through a three point connection; (2) the upper surface is a folding hexagonal truss plate mechanism which serves as the supporting structure for a reflective surface; and (3) the entire truss and surface can be folded into a cylindrical envelope in which all truss elements are essentially parallel. The kinematic studies and engineering demonstration model fully verified the deployment kinematics, stowing philosophy, and deployment sequencin for large antenna modules. It was established that such modules can be stowed in packages as small as 25 cm in diameter, using 1.27 cm diameter structural tubes. The development activity indicates that this deployable modular approach towards building large structures in space will support erection of 450 m apertures for operation up to 3 GHz with a single space shuttle flight. A.R.H.

N82-11493*# Howard Univ., Washington, D. C.
**STUDY OF FOLDABLE ELASTIC TUBES FOR LARGE SPACE
 STRUCTURE APPLICATIONS, PHASE 3 Final Report**
 I. W. JONES and S. O. MITCHELL Sep. 1981 46 p refs
 (Contract NSG-1320)
 (NASA-CR-164929) Avail: NTIS HC A03/MF A01 CSCL 20K

A bi-convex foldable elastic tube, suitable for use in self deploying space structures, was subjected to a series of buckling tests to determine initial buckling loads, collapse loads, and the buckling mode. The tube is cylindrical with a cross-section that is lenticular-like with flared edges. It is capable of being flattened in the center and folded compactly, storing up strain energy in the process. Upon removal of constraint, it springs back to its original straight configuration, releasing the stored strain energy. The tests showed that this type of tube has good resistance to buckling, with the initial buckling loads all falling within or above the range of those for comparable circular cylindrical tubes. M.G.

N82-12472*# General Research Corp., Santa Barbara, Calif.
**TEST PROGRESS ON THE ELECTROSTATIC MEMBRANE
 REFLECTOR**
 D. J. MIHORA Hampton, Va. NASA. Langley Research
 Center 29 Jun. 1981 129 p refs
 (Contract NAS1-16133)
 (NASA-CR-165792; CR-2-998) Avail: NTIS HC A07/MF A01
 CSCL 20K

An extremely lightweight type of precision reflector antenna, being developed for potential deployment from the space shuttle, uses electrostatic forces to tension a thin membrane and form it into a concave reflector surface. The typical shuttle-deployed antenna would have a diameter of 100 meters and an RMS surface smoothness of 10 to 1 mm for operation at 1 to 10 GHz. NASA Langley Research Center built and is currently testing a subscale (16 foot diameter) model of the membrane reflector portion of such an antenna. Preliminary test results and principal factors affecting surface quality are addressed. Factors included are the effect of the perimeter boundary, splicing of the membrane, the long-scale smoothness of commercial membranes, and the spatial controllability of the membrane using voltage adjustments to alter the electrostatic pressure. Only readily available commercial membranes are considered. A.R.H.

N82-15366*# Astro Research Corp., Carpinteria, Calif.
**LIGHTWEIGHT MOVING RADIATORS FOR HEAT REJECTION
 IN SPACE Final Report**
 K. KNAPP 10 Nov. 1981 50 p refs
 (Contract NAS8-34191)
 (NASA-CR-161943; ARC-TN-1107) Avail: NTIS HC A03/MF
 A01 CSCL 20D

Low temperature droplet stream radiators, using nonmetallic fluids, can be used to radiate large amounts of waste heat from large space facilities. Moving belt radiators are suitable for use on a smaller scale, radiating as few as 10 kW from shuttle related operations. If appropriate seal technology can be developed, moving belt radiators may prove to be important for high temperature systems as well. Droplet stream radiators suitable for operation at peak temperatures near 300 K and 1000 K were studied using both freezing and nonfreezing droplets. Moving belt radiators were also investigated for operation in both temperature ranges. The potential mass and performance characteristics of both concepts were estimated on the basis of parametric variations of analytical point designs. These analyses included all consideration of the equipment required to operate the moving radiator system and take into account the mass of fluid lost by evaporation during mission lifetimes. Preliminary results indicate that low temperature droplet stream radiator appears to offer the greatest potential for improvement over conventional flat plate radiators. A.R.H.

N82-16160*# National Aeronautics and Space Administration.
 Langley Research Center, Hampton, Va.
**PRELIMINARY DESIGN OF TETRAHEDRAL TRUSS
 REFLECTOR STRUCTURE**
 M. F. CARD and J. K. JENSEN (Kentron International, Inc.) *In
 its* The Microwave Radiometer Spacecraft p 95-107 Dec. 1981
 refs

Avail: NTIS HC A11/MF A01 CSCL 22B

A baseline structure proposed for the microwave radiometer spacecraft (MRS) reflector is a large graphite-epoxy truss. The truss structure was selected to provide adequate stiffness to minimize control problems and to provide a low-expansion 'strong back' on which to mount and control reflector mesh panels. Details of the structural members, joints and assembly concepts are presented, a concept for the reflector mesh surface is discussed, and preliminary estimates of the mass and structural natural frequencies of the reflector system are presented. Author

N82-16493*# Astro Research Corp., Carpinteria, Calif.
**EFFICIENT STRUCTURES FOR GEOSYNCHRONOUS
 SPACECRAFT SOLAR ARRAYS. PHASE 1, 2 AND 3 Final
 Report**
 L. R. ADAMS and J. M. HEDGEPEETH 14 Sep. 1981 102 p
 refs Prepared for JPL
 (Contract NAS7-100; JPL-955647)
 (NASA-CR-163471; ARC-TN-1098; JPL-9950-626) Avail: NTIS
 HC A06/MF A01 CSCL 10A

Structural concepts for deploying and supporting lightweight solar-array blankets for geosynchronous electrical power are evaluated. It is recommended that the STACBEAM solar-array system should be the object of further study and detailed evaluation. The STACBEAM system provides high stiffness at low mass, and with the use of a low mass deployment mechanism, full structural properties can be maintained throughout deployment. The stowed volume of the STACBEAM is acceptably small, and its linear deployment characteristic allows periodic attachments to the solar-array blanket to be established in the stowed configuration and maintained during deployment. N.W.

N82-18282*# National Aeronautics and Space Administration.
 Langley Research Center, Hampton, Va. Structures and Dynamics
 Div.

**VIBRATION AND BUCKLING STUDIES OF PRETENSIONED
 STRUCTURES**

W. K. BELVIN *In its* Large Space Systems Technol., 1981 p
 109-121 Mar. 1982

Avail: NTIS HC A19/MF A01 CSCL 22B

Results of analyses and tests of a simple pretensional structure are presented. Linear finite element analysis correlated well with experimental small amplitude vibration data. The buckling and vibration behavior of a pretensional stayed column was studied in detail. The bifurcation buckling load was also predicted accurately. Postbuckling behavior of the column was unusual and results in a post buckling restoring force of only 1/64 the bifurcation buckling load. Interaction between lateral accelerations and compressive load creates isolated stay slackening at loads above 50 percent of the buckling load. Further research will be required to fully understand their impact on the use of pretensioned structures as large space structures. M.D.K.

N82-18288*# Astro Research Corp., Carpinteria, Calif.
SEQUENTIAL DEPLOYMENT OF TRUSS STRUCTURES
 J. M. HEDGEPEETH *In* NASA. Langley Research Center Large
 Space Systems Technol., 1981 p 179-192 Mar. 1982
 Avail: NTIS HC A19/MF A01 CSCL 22B

The geometry investigated most intensively was the triangular tetrahedral truss. A square type truss having the same topology was also investigated. The tetrahedral truss is composed of surface struts and core members. In the deployable form, the entire truss is viewed as being made up of a number of parallel truss ribs connected to each other by interrib struts and members. The packaging efficiency of the truss was evaluated. T.M.

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N82-18626*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

GENERAL DESCRIPTION OF NESTABLE COLUMN STRUCTURAL AND ASSEMBLY TECHNOLOGY

H. G. BUSH and W. L. HEARD, JR. Dec. 1981 16 p refs (NASA-TM-83255) Avail: NTIS HC A02/MF A01 CSCL 20K

The superior packaging characteristics of nestable column structural elements make this concept attractive for application to missions space shuttle missions requiring large and/or high stiffness, or complex structures. Photographs depict investigations pursued relative to defining structural and assembly technology using these structural elements. The neutral buoyancy facility assembly simulation tests and the large space structure mobile work station are featured. A.R.H.

N82-19274*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ELECTROSTATIC MEMBRANE ANTENNA CONCEPT TESTING Progress Report

J. W. GOSLEE *In its* Large Space Systems Technol., Pt. 2, 1981 p 681-688 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The electrostatic concept is evaluated to determine its feasibility for future antenna applications. The concept tested illustrates how the individual power supplies are connected to concentric electrodes located in back of the plastic membrane which is the reflective surface. L.F.M.

N82-19275*# Martin Marietta Aerospace, Denver, Colo.

CONCEPTUAL DESIGN OF ELECTROSTATIC ANTENNA

J. V. COYNER *In* NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 689-707 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The concept of using electrostatic forces to tension a thin, conducting membrane and maintain it in a precision antenna shape is discussed. This electrostatically controlled membrane mirror is an adaptive structure which maintains surface quality despite errors in construction, irregularities of materials, solar heating, and on board disturbances. L.F.M.

N82-19286# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).

THERMOELASTIC DEFORMATION IN CYLINDRICAL SHELLS OF GREAT LENGTH [DEFORMACAO TERMOELASTICA EM CASCAS CILINDRICAS DE GRANDE ALONGAMENTO]

W. BORUSZEWSKI Nov. 1981 14 p refs *In* PORTUGUESE; ENGLISH summary Presented at the INPE-LCC Seminar, Rio de Janeiro, 25-27 Nov. 1981

(INPE-2268-PRE/049) Avail: NTIS HC A02/MF A01

The utilization of long and slender cylindrical shells, as flexible appendages of satellites, is presented intending to introduce the problem of bending and torsion of thermoelastic origin. A finite element method approach to this problem is proposed. S.L.

04

STRUCTURAL DYNAMICS AND CONTROL

Includes modeling, systems identification, attitude and control techniques and systems, surface accuracy measurement and control techniques and systems, sensors, and actuators.

A82-10091*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MANAGEMENT OF THE GALILEO ATTITUDE AND ARTICULATION CONTROL FLIGHT SOFTWARE DEVELOPMENT

G. D. PACE and H. K. BOUVIER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) *In: Computers in Aerospace Conference, 3rd, San Diego, CA, October 26-28, 1981, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1981, p. 112-118. NASA-supported research.*

(AIAA 81-2127)

Management concepts are presented for software development for a new technology area, i.e., real-time autonomous, computer-based spacecraft control. Flight computer selection and sizing are done initially to maximize performance within constraints of size, power, and cost. A higher order language is chosen to enhance productivity. Because the computer is embedded in the control systems hardware and is tied to the iterative design process of the spacecraft, the management and configuration control of the software is different from more typical applications. The development process must permit early coding but accept late changes. Margin management must be a continuing process in the development. Validation and verification is a special problem because it is not feasible to test the software in the actual operating environment prior to launch. (Author)

A82-12508#

ASPECTS OF CONTROL IN LARGE SPACE STRUCTURES

P. SANTINI (Roma, Universita, Rome, Italy) *In: International Scientific Conference on Space, 21st, Rome, Italy, March 25, 26, 1981, Proceedings. Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1981, p. 91-95. refs*

Noting that future large space structures (LSS) such as the SPS, communications satellites, and antennas will require a beam amplitude of less than 0.1, vibration amplitudes of less than 0.005, and surface distortion less than 1 mm, a model for the control-structure interaction is formulated qualitatively. Considering it an impossibility to effectively control all the parameters of structural frequencies, eigenmodes, and local characteristics, use of modal synthesis is suggested as an alternative to attempting active control of every factor. A feedback control of the first N modes is applied to a discretized system, obtained by truncation of the eigenmodes of the structural operator, and incorporating a priori conditions to avoid uncontrolled modes. Repeated implementation of hierarchical control techniques are proposed as an effective means to reduce propellant mass consumption. M.S.K.

A82-12621* Bendix Corp., Southfield, Mich.

APPLICATION OF GAUSS-SEIDEL MULTILEVEL CONTROL TO A SINGLE AXIS TORSIONAL MODEL

F. D. CHICHESTER (Bendix Corp., Southfield, MI) *In: The Space Shuttle - Its current status and future impact; Proceedings of the Aerospace Congress and Exposition, Los Angeles, CA, October 13-16, 1980. Warrendale, PA, Society of Automotive Engineers, Inc., 1981, p. 61-65. refs*

(Contract NAS8-33979)

An approach to the application of multilevel control techniques for large space structures is presented. Gauss-Seidel second level controls and an extension of standard linear quadratic regulator techniques are applied to a model consisting of a flexible space vehicle comprising three rigid bodies rotating about a common axis. The method incorporates second order derivatives with

respect to time, entailing the use of a two level hierarchy of subsystems. Gauss-Seidel second level control formulations were chosen to avoid the necessity of having as many controls as constraints or using gradient techniques in the choice of the Hamiltonian. The modular nature of the resulting control system allows applications for spacecraft with larger numbers of modules. D.H.K.

A82-12624

STRUCTURAL MODELING FOR CONTROL DESIGN OF A LARGE SOLAR ARRAY

C. S. GREENE, G. STEIN, and R. E. POPE (Honeywell Systems and Research Center, Minneapolis, MN) In: The Space Shuttle - Its current status and future impact; Proceedings of the Aerospace Congress and Exposition, Los Angeles, CA, October 13-16, 1980. Warrendale, PA, Society of Automotive Engineers, Inc., 1981, p. 83-87. refs

The modeling and control design of the Power Extension Package (PEP), to be deployed from the Shuttle bay by the Remote Manipulator System, is described. The power package is regarded as the first Large Space Structure (LSS), having performance and disturbance rejection requirements which impose control bandwidths near the frequency range of structural resonances. Modeling fidelity is found to be a critical component of control design for LSS, and is discussed for the PEP in terms of the sun pointing control. Orbiter maneuvering rates, plume loads, and structural dynamics are examined, and it is noted that the control loop must be phase stable over a wide frequency range, with final crossover occurring at a hundred times the nominal rigid body crossover. D.H.K.

A82-13094

DIGITAL CONTROL FOR FLEXIBLE AIRCRAFT USING REDUCED ORDER MODELS

G. L. SLATER and R. KANDADAI (Cincinnati, University, Cincinnati, OH) In: Joint Automatic Control Conference, Charlottesville, VA, June 17-19, 1981, Proceedings. Volume 1. New York, American Institute of Chemical Engineers, 1981, 6 p. (WP-1E). refs

A control synthesis is presented for a very flexible aircraft, and the effects on performance from different types of suboptimal approximations are compared. By examining the response at varying sample rates, it is shown that there is a tradeoff between model accuracy and computational feasibility. When the computational requirements of higher-order models are considered, the slow sample rates imposed by these requirements make the reduced order model a superior controller B.J.

A82-13671

GREEN-TYPE FORMULAS FOR A FLEXURALLY VIBRATING PLATE [O FORMULAKH TIPI FORMUL GRINA DLIA IZGIBNO KOLEBLIUSHCHEISIA PLASTINY]

B. P. BELINSKII and D. P. KOUZOV (Leningradskii Gosudarstvennyi Universitet, Leningrad, USSR) Akusticheskii Zhurnal, vol. 27, Sept.-Oct. 1981, p. 710-718. In Russian. refs

Formulas analogous to Green's formulas have been obtained for flexurally vibrating plates including an individual plate in an acoustic medium and a rib-stiffened plate. The relationship between the formulas and the duality principle in Lyamshev's formulation (1964) is discussed along with applications of the formulas. V.L.

A82-13970*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ON INCORPORATING RELIABILITY CONSIDERATIONS INTO CONTROL SYSTEM DESIGNS

R. C. MONTGOMERY, G. C. HORNER (NASA, Langley Research Center, Hampton, VA), I. I. AKPAN (Old Dominion University, Norfolk, VA), and W. E. VANDERVELDE (MIT, Cambridge, MA) Institute of Electrical and Electronics Engineers, Conference on Decision and Control, 20th, San Diego, CA, Dec. 16-18, 1981, Paper. 3 p.

This paper considers reliability in designing control systems for large orbital structures that are expected to have appreciable flexibility. Reliability is considered for both the control configuration

(i.e. selecting sensor and actuator locations over an admissible set) and the ultimate operation of the system. The approach presented is to construct a cost function that indicates the absolute goal of the system and, for a given structural design, to determine the lowest achievable costs conditioned on the failure states of the system (i.e. which actuators and sensors are operational). These costs are then weighted and summed to provide an overall system performance measure. This measure is then minimized over the set of admissible control configurations. The approach is illustrated using a beam that has four actuators with the goal of achieving a given parabolic shape. (Author)

A82-13998*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

EXPERIMENTAL DEMONSTRATION OF STATIC SHAPE CONTROL

D. ELDRED and D. SCHAECHTER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) American Institute of Aeronautics and Astronautics, Guidance and Control Conference, Albuquerque, NM, Aug. 19-21, 1981, 17 p (Contract NAS7-100) (AIAA PAPER 81-1785)

Results of a microprocessor-controlled implementation of static shape control using a specially constructed flexible beam facility are presented. The discussion covers the development of shape control algorithms, adaptation of the algorithms for use with finite element models, construction of a flexible beam, characterization and calibration of the facility, development of a finite element model for the beam, and the development of computer hardware and software. It is shown that feedback control yields better results than open-loop control, and that the use of more than two sensors in the control loop has little effect on the system performance. V.L.

A82-13999#

FREQUENCY-SHAPING METHODS IN LARGE SPACE STRUCTURES CONTROL

N. K. GUPTA, M. G. LYONS (Integrated Systems, Inc., Palo Alto, CA), J.-N. AUBRUN, and G. MARGULIES (Lockheed Research Laboratories, Palo Alto, CA) American Institute of Aeronautics and Astronautics, Guidance and Control Conference, Albuquerque, NM, Aug. 19-21, 1981, 15 p. refs (AIAA PAPER 81-1783)

The dynamics of large space structures are characterized by a continuum of poorly damped modes which make achievement of control objectives difficult. Feedback control mechanizations to improve system performance must provide measurable robustness. Vibration propagation from on-board sources must be controlled to reduce performance degradation. The paper applies frequency-shaping methods to the control of systems with poorly damped modes where only a subset of low-frequency modes is known accurately. Analytical techniques are reviewed and design examples are presented to show the application of the method to practical structures. (Author)

A82-14452

MOTION OF A SPACECRAFT WITH A FLEXIBLE SOLAR ARRAY

V. S. KHOROSHILOV (Kosmicheskie Issledovaniia, vol. 19, May-June 1981, p. 336-345.) Cosmic Research, vol. 19, no. 3, Nov. 1981, p. 226-234. Translation. refs

(For abstract see issue 18, p. 3087, Accession no. A81-40277)

A82-16186

STRONG STABILIZABILITY AND THE STEADY STATE RICCATI EQUATION

A. V. BALAKRISHNAN (California, University, Los Angeles, CA) Applied Mathematics and Optimization, vol. 7, Nov. 1981, p. 335-345. refs (Contract AF-AFOSR-78-3550)

Strong stabilizability (as opposed to exponential stabilizability) is investigated with the aid of the steady state Riccati equation. It

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is shown that the latter can have at most one strongly stable solution, and some sufficient conditions for existence are obtained. An application is also indicated to steady state Kalman filtering where the observation operator is compact so that exponential stability may not exist. (Author)

A82-16327

MAGNETIC CONTROL AND THE 25 KW POWER SYSTEM

J. H. DECANINI, H. FLASHNER, and H. SCHMEICHEL (TRW Defense and Space Systems Group, Redondo Beach, CA) In: Guidance and control 1981; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, January 31-February 4, 1981. San Diego, CA, Univelt, Inc., 1981, p. 71-93. refs
(AAS 81-004)

Previously unpublished studies and applications of magnetic control to earth-orbiting space vehicles are surveyed, and the results of an investigation of the momentum storage and unloading requirements of a reference 25 kW power system design are presented. These requirements, due to disturbance torques, are listed for both peak and accumulated momentum. Existing techniques for momentum control are assessed, and it is shown that a bang-bang cross product law provides adequate results with a very simple system configuration. The minimum control law requires greater magnetic configuring capability and more complex operations on board the vehicle. The development of new methods for disturbance momentum management is discussed. J.F.

A82-16328

MAGNETIC CONTROL SYSTEMS FOR SATELLITES IN SYNCHRONOUS ORBIT

R. GRAN and M. PROISE (Grumman Aerospace Corp., Bethpage, NY) In: Guidance and control 1981; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, January 31-February 4, 1981. San Diego, CA, Univelt, Inc., 1981, p. 117-140. International Telecommunications Satellite Organization refs
(Contract INTELSAT-INTEL-064)
(AAS 81-006)

Following an overview of the Orbiting Astronomical Observatory and its flight operational characteristics, a newly developed synchronous orbit communication satellite attitude control system is described. The control system uses a magnetic coil wrapped around the solar array in conjunction with a three-axis reactor wheel system. It was demonstrated that the control system can provide performance characteristics better than ± 0.1 deg accuracy in the presence of (1) attitude and rate gyro sensing noise, (2) torque disturbances due to solar pressure on the vehicle, and (3) measurable magnetic field variations. The effect of the structural excitations created by the distributed forces of the magnetic coil acting on the solar array was analyzed, showing that when high gains are imposed on the magnetic control loop, unstable structural bending modes in roll can result. These modes can be desensitized, however, by including magnetic coil dynamics at or near the attitude control system bandpass. J.F.

A82-17885#

OPTIMALITY CONDITIONS FOR FIXED-ORDER DYNAMIC COMPENSATION OF FLEXIBLE SPACECRAFT WITH UNCERTAIN PARAMETERS

D. C. HYLAND (MIT, Lexington, MA) American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 20th, Orlando, FL, Jan. 11-14, 1982, 12 p. USAF-sponsored research. refs
(AIAA PAPER 82-0312)

This paper gives explicit optimality conditions for constant gain, fixed-order compensation of structural systems with non-singular observation noise. The results are derived under a stochastic design model reflecting possible a priori uncertainties in the plant dynamics and thus represent an extension of the minimum information stochastic design approach developed earlier for more restricted controller forms. By judicious choice of the compensator dynamics matrix, the optimality conditions are shown to reduce to relatively

simple forms. These conditions clearly display the central role played by the projection (idempotent operator) defining the compensator control and observation subspaces. (Author)

A82-18869

VIBRATIONS OF COMPLEX ELASTIC SYSTEMS [KOLEBANIYA SLOZHNYKH UPRUGIKH SISTEM]

F. M. DIMENTBERG, (ED.) Moscow, Izdatel'stvo Nauka, 1981. 104 p. In Russian.

A number of papers on vibrations in complex mechanical systems (i.e., solids connected with elastic elements) are presented. Particular attention is given to the use of group theory to study the dynamics of regular and quasi-regular systems, the use of the method of subsystems to analyze the vibrations of hybrid mechanical systems, and the automated formation of the dynamic stiffness matrix of a complex mechanical system. The frequency density distribution of lumped-parameter systems, the use of simulation to analyze the natural frequencies of a linear oscillatory system, and the vibrations of a flexible pendulum on an elastic suspension are also examined. B.J.

A82-19320#

DYNAMICS OF A DEPLOYING ORBITING BEAM-TYPE APPENDAGE UNDERGOING LIBRATIONS

K. W. LIPS and V. J. MODI (British Columbia, University, Vancouver, Canada) American Society of Mechanical Engineers, Design Engineering Technical Conference, Hartford, CT, Sept. 20-23, 1981, 7 p. refs
(ASME PAPER 81-DET-63) MEMBERS, \$2.00; NONMEMBERS, \$4.00

Vibration characteristics associated with a deploying spacecraft appendage in an arbitrary orbit are investigated numerically. In the beginning a rather general formulation of the problem is presented which accounts for the shifting center of mass, appendage offset, arbitrary variation of flexural rigidity along the appendage length, deployment acceleration, and satellite librations. The governing nonlinear, nonautonomous, and coupled equations are not amenable to any closed form solution. To gain some appreciation as to the character of the motion, the linearized equations are solved in a quasisteady fashion using the assumed mode procedure over a range of system parameters. Effects of pure flexure, spin, deployment, and orbital motion are isolated and their relative importance established. Although the deployment rate tends to introduce instability, it is the deployment related Coriolis loading which may lead to excessive displacements, particularly if the deployment time is too long. The information should prove useful during the attitude acquisition phase when interactions between the control system, structural flexibility, and vehicle dynamics are particularly significant. (Author)

A82-19321#

VIBRATION ANALYSIS OF A FLEXIBLE SYSTEM MOUNTED ON A VISCOELASTIC SANDWICH BEAM

R. C. DAS VIKAL (Muzaffarpur Institute of Technology, Muzaffarpur, India), K. N. GUPTA, and B. C. NAKRA (Indian Institute of Technology, New Delhi, India) American Society of Mechanical Engineers, Design Engineering Technical Conference, Hartford, CT, Sept. 20-23, 1981, 8 p. refs
(ASME PAPER 81-DET-64) MEMBERS, \$2.00; NONMEMBERS, \$4.00

Vibration analysis of a simple flexible system mounted arbitrarily on a three-layer sandwich beam having a viscoelastic core and elastic faces is presented in this paper. The flexible system consists of a mass on rubber spring and is excited harmonically. The expressions for displacement response of mass and transmissibility provided by the whole system are obtained. The displacement response and transmissibility are studied for different geometrical and physical parameters of the sandwich beam. Some of the theoretical results are verified experimentally. (Author)

A82-19472

NONLINEAR EQUATIONS OF MOTION OF LARGE MULTIBODY SYSTEMS [NICHTLINEARE BEWEGUNGSGLEICHUNGEN GROSSER MEHRKOERPERSYSTEME]

W. SCHIEHLEN (Stuttgart, Universitaet, Stuttgart, West Germany) Zeitschrift fuer angewandte Mathematik und Mechanik, vol. 61, Sept. 1981, p. 413-419. In German. refs

An investigation is conducted regarding the general structure of the equations of motion of nonlinear holonomic multibody systems, taking into account the dependence of the employed coordinates and principles. A method of deriving symbolic equations of motion for large ordinary multibody systems is discussed. The procedures of the method are suited for an implementation involving the use of a computer. The application of Jourdain's principle makes it possible to obtain the equations of motion in a greatly simplified form. The relation between the obtained equations and the equations of motion derived with the aid of the D'Alembert principle or the Lagrange equations of the second kind can be established by means of congruence transformations. Attention is also given to the linearization of the equations of motion. G.R.

A82-21156

MULTI-BODY DYNAMICS INCLUDING THE EFFECTS OF FLEXIBILITY AND COMPLIANCE

R. L. HUSTON (Cincinnati, University, Cincinnati, OH) Computers and Structures, vol. 14, no. 5-6, 1981, p. 443-451. refs (Contract N0014-76-C-0139)

New and recently developed concepts and ideas useful in obtaining efficient computer algorithms for solving the equations of motion of multi-body mechanical systems with flexible links are presented and discussed. These ideas include the use of Euler parameters. Lagrange's form of d'Alembert's principle, generalized speeds, quasi-coordinates, relative coordinates, and structural analysis techniques. The mechanical systems considered are linked bodies forming a tree structure, but with no 'closed loops' permitted. An explicit formulation of the governing equations is presented.

(Author)

A82-21172

ROBUST INVERSE OPTIMAL CONTROL FOR FLEXIBLE STRUCTURES

A. ARBEL (Systems Control, Inc., Mountain View, CA) and N. K. GUPTA (Integrated Systems, Inc., Palo Alto, CA) Journal of Optimization Theory and Applications, vol. 35, Nov. 1981, p. 403-416. refs (Contract N00014-77-C-0247)

An inverse optimal control problem is formulated to develop robust control laws for purely oscillatory systems. The optimal control solution requires output feedback with specified constraints, leading to robustness with respect to unmodeled modes and a large class of parameter variations. The robustness properties are proved directly from known properties of control laws resulting from quadratic performance indices. The control laws are useful for poorly damped flexible structures.

(Author)

A82-21939*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ESTIMATION OF DISTRIBUTED PARAMETER SYSTEMS

D. B. SCHAECHTER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) Journal of Guidance, Control and Dynamics, vol. 5, Jan.-Feb. 1982, p. 22-26. refs (Contract NAS7-100)

The estimation and control of large flexible space structures pose significant new control technology problems. One major problem area is the closed-loop stability of a structure that has been modeled with truncated modal dynamics. Stability problems arise due to the control design process beginning with a deficient model. This work provides the necessary conditions for the optimal estimation of infinite dimensional (partial-differential equation) systems. This approach can be particularly useful for initial control studies and for gaining considerable insight into what the optimal estimator for a truly infinite dimensional system should be. A

detailed example of the estimation of the continuous shape of a string in tension is presented. (Author)

A82-23481#

THE ANTENNA POINTING SYSTEMS FOR LARGE COMMUNICATION SATELLITE

J. BROQUET, B. GOVIN, and J. C. AMIEUX (Matra, S.A., Velizy-Villacoublay, Yvelines, France) In: Communications Satellite Systems Conference, 9th, San Diego, CA, March 7-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 40-48. (AIAA 82-0444)

Very accurate antenna pointing (0.05 deg, 3 sigma at antenna electrical axis level) typically implies the direct measurement of antenna orientation through the use of an RF sensor incorporated in each antenna, mechanical decoupling between antennas to allow for compensation of structural deformations, and mechanical decoupling between each antenna and the satellite main body through the use of antenna pointing mechanisms (APM) to allow for high antenna control bandwidth. This paper briefly describes concepts of APM and associated control, and pointing performances of attitude control concept alternatives are shown for a typical payload. B.J.

A82-24795

OPTIMAL CONTROL OF DISTRIBUTED SYSTEMS

J. A. BREAKWELL (Lockheed Research Laboratories, Palo Alto, CA) Journal of the Astronautical Sciences, vol. 29, Oct.-Dec. 1981, p. 343-372. refs

A method for applying optimal control theory to a system described by partial differential equations is presented. An optimal steady-state regulator is designed as an example of a flexible spacecraft. The behavior of the spacecraft under the influence of the optimal control system is described, and the means of obtaining a distributed gain function to implement the optimal control is given. The new globally stabilizing distribution gain is compared with another globally stabilizing technique (Lyons et al., 1979). It is concluded that there exists a new type of feedback control which can be used to give global stabilization and to overcome destabilization owing to parameter deviation. J.F.

A82-24815*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

CONSTRAINED AND UNCONSTRAINED MODES - SOME MODELING ASPECTS OF FLEXIBLE SPACECRAFT

H. B. HABLANI (NASA, Johnson Space Center, Houston, TX; Purdue University, West Lafayette, IN) Journal of Guidance, Control, and Dynamics, vol. 5, Mar.-Apr. 1982, p. 164-173. refs (Contract JPL-955639)

Spacecraft that are partially rigid and partially flexible may be dynamically modeled in terms of either 'constrained' modes of vibration, for which the rigid part is held motionless, or the 'unconstrained' modes of the whole vehicle. A model 'completeness index' is defined for each expansion and used as a truncation criterion. Using as an example a large flexible platform with a rigid body at the center, it is shown that as the rigid portion of the vehicle becomes very small, a great many constrained modes are needed to achieve satisfactory model completeness. Otherwise, one finds an erroneous distribution of angular momentum among the modes. It is also shown that the importance of unconstrained modes is not necessarily ordered by frequency. (Author)

A82-25569

THREE STEPS TO ALLEVIATE CONTROL AND OBSERVATION SPILLOVER PROBLEMS OF LARGE SPACE STRUCTURES

J. G. LIN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) In: Conference on Decision and Control, 19th, and Symposium on Adaptive Processes, Albuquerque, NM, December 10-12, 1980, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 438-444. refs (Contract F30602-80-C-0096)

It is pointed out that control (observation) spillover may be prevented by proper placement of actuators (sensors). If proper

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placement is not possible owing to structural constraints, control spillover to (observation spillover from) secondary modes can still be prevented by synthesizing the existent actuator (sensor) influences. Alternatively, control spillover to (observation spillover from) nonprimary modes can be reduced by adding some bandstop filter to each input (output) channel. The underlying theoretical foundation of a proposed three-step approach for alleviating spillover problems is presented, along with conditions and techniques for proper placement, proper synthesis, and proper filtering. Also included is an illustrative numerical example. C.R.

A82-25587

MODAL COST ANALYSIS OF FLEXIBLE SPACE STRUCTURES WITH UNCERTAIN MODAL DATA

R. E. SKELTON and R. YEDAVALLI (Purdue University, West Lafayette, IN) In: Conference on Decision and Control, 19th, and Symposium on Adaptive Processes, Albuquerque, NM, December 10-12, 1980, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 792-794. refs

The present investigation has the aim to extend the concepts of open loop modal cost analysis to space structures with uncertain modal data to determine the critical modes and critical parameters for the given performance objectives. The extension makes it possible to obtain explicit analytical formulas which can be calculated for a large number of modes to determine the desired modes and parameters of the structure. The information provided by the considered approach can be useful in problems related to the redesign of the structure, the redesign of finite element models, and aspects of parameter estimation G.R.

A82-25588* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

PARAMETER IDENTIFICATION OF CIVIL ENGINEERING STRUCTURES

J. N. JUANG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) and C. T. SUN (Purdue University, West Lafayette, IN) In: Conference on Decision and Control, 19th, and Symposium on Adaptive Processes, Albuquerque, NM, December 10-12, 1980, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 802, 803.

This paper concerns the development of an identification method required in determining structural parameter variations for systems subjected to an extended exposure to the environment. The concept of structural identifiability of a large scale structural system in the absence of damping is presented. Three criteria are established indicating that a large number of system parameters (the coefficient parameters of the differential equations) can be identified by a few actuators and sensors. An eight-bay-fifteen-story frame structure is used as example. A simple model is employed for analyzing the dynamic response of the frame structure.

(Author)

A82-25589* Vigyan Research Associates, Inc., Hampton, Va.
DAMPING ENHANCEMENT AND ATTITUDE CONTROL OF LARGE SPACE STRUCTURES

S. M. JOSHI (Vigyan Research Associates, Inc., Hampton, VA) In: Conference on Decision and Control, 19th, and Symposium on Adaptive Processes, Albuquerque, NM, December 10-12, 1980, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 804-806. (Contract NAS1-16126)

Enhancement of modal damping in large space structures (LSS) is highly desirable and sometimes essential for the stability of the primary attitude control system. This paper considers the use of a number of Annular Momentum Control Devices (AMCD's) for damping enhancement in LSS. It is proved that the closed-loop system is stable in the sense of Lyapunov. Sufficient conditions for asymptotic stability are also obtained. (Author)

A82-25608

CONSTRAINED OPTIMAL COMPENSATOR DESIGN FOR LARGE FLEXIBLE SPACECRAFT CONTROL

J. R. SESA, R. V. HALSTENBERG, Y. CHANG, and J. A. BROADBENT (General Dynamics Corp., Convair Div., San Diego, CA) In: Conference on Decision and Control, 19th, and Symposium on Adaptive Processes, Albuquerque, NM, December 10-12, 1980, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 994-998. refs

This paper considers the compensator problem of optimal control and estimation theory and advances a new design technique that constrains the optimal compensator. The technique works directly through suitable static constraints placed in the optimal performance index. The basic goal is compensator stability; however, for certain classes of systems, the technique may yield positive real compensation and thus provide hyperstability for certain classes of flexible spacecraft. (Author)

A82-25609

CHALLENGES IN STABLE AND ROBUST CONTROL SYSTEM DESIGN FOR LARGE SPACE STRUCTURES

R. P. IWENS (TRW Defense and Space Systems Group, Redondo Beach, CA) In: Conference on Decision and Control, 19th, and Symposium on Adaptive Processes, Albuquerque, NM, December 10-12, 1980, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 999-1002. refs

An approach to designing stable and high performance control systems for large space structures is discussed. Stability with robustness is achieved through the application of a technique based on the positivity of operators. High performance is achieved through on-orbit control system tuning using either indirect or direct adaptive control. (Author)

A82-25610* Rensselaer Polytechnic Inst., Troy, N. Y.

CLOSED-LOOP STABILITY OF LARGE SPACE STRUCTURES VIA SINGULAR AND REGULAR PERTURBATION TECHNIQUES - NEW RESULTS

M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) In: Conference on Decision and Control, 19th, and Symposium on Adaptive Processes, Albuquerque, NM, December 10-12, 1980, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1003-1005. refs (Contract NAS9-16053)

Large Space Structures are treated as a special class of highly oscillatory distributed parameter systems. Practical controllers will need to be finite dimensional; however, this calls the closed-loop stability into question due to spillover interactions. Recent results, obtained using regular and singular perturbations theory, give stability bounds for closed-loop control of this type of distributed parameter system; this paper surveys these results and their implications for large space structures. (Author)

A82-25621

STUDY OF VELOCITY OUTPUT VIBRATION SUPPRESSION CONTROLLERS WITH A MULTILoop ROOT LOCUS

D. C. HERRICK (USAF, Weapons Laboratory, Kirtland AFB, NM) In: Conference on Decision and Control, 19th, and Symposium on Adaptive Processes, Albuquerque, NM, December 10-12, 1980, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1088-1090. refs

A multiloop root locus technique used to study velocity output feedback controllers in very lightly damped structures is described. It is shown in particular that finite zeros are a characterization of the rank deficiency of the controller. It is also shown that one design procedure artificially eliminates these zeros from the design model. Relative departure rates, infinite asymptote attraction rates, and finite zeros can be used in combination for predicting general root locus behavior. The eigenproblems for each of these characteristics indicate strategies for gain selection and sensor/actuator placement. Attention is also given to the applicability to large space structures. C.R.

A82-25637

A CONTROL DESIGN ALGORITHM FOR FLEXIBLE STRUCTURES

R. E. SKELTON (Purdue University, West Lafayette, IN) In: Conference on Decision and Control, 19th, and Symposium on Adaptive Processes, Albuquerque, NM, December 10-12, 1980, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1232-1234. refs

A design procedure is proposed that uses rate feedback to provide damping on a higher number of modes ($N_{sub L}$) than the optimal controller uses ($N_{sub C}$). The control and observation spillover of these ($N_{sub L} - N_{sub C}$) modes must therefore push these poles a greater distance to destabilize them. This is accomplished only in an integrated design, such as proposed here. This is so because, in general, the modes which are damped by rate feedback and the modes which have large control and observation spillover consequences from the outer loop control design might not be the same. C.R.

A82-25639* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

AN IMPROVED OUTPUT FEEDBACK CONTROL OF FLEXIBLE LARGE SPACE STRUCTURES

Y. H. LIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) and J. G. LIN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) In: Conference on Decision and Control, 19th, and Symposium on Adaptive Processes, Albuquerque, NM, December 10-12, 1980, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1248-1250. refs
(Contract NAS7-100; F30602-80-C-0096)

A special output feedback control design technique for flexible large space structures is proposed. It is shown that the technique will increase both the damping and frequency of selected modes for more effective control. It is also able to effect integrated control of elastic and rigid-body modes and, in particular, closed-loop system stability and robustness to modal truncation and parameter variation. The technique is seen as marking an improvement over previous work concerning large space structures output feedback control. C.R.

A82-26612

FLEXIBLE SPACECRAFT ATTITUDE MEASUREMENT AND CONTROL SCHEME INCORPORATING STATE ESTIMATION

J. FENTON, D. HORTON, and K. F. GILL (Leeds University, Leeds, England) Optimal Control Applications and Methods, vol. 3, Jan.-Mar. 1982, p. 23-40. refs

The design of an attitude measurement and control scheme for a flexible space vehicle is presented. A proposed spacecraft configuration is used to study the performance of an inertial-optical measurement system incorporating a Kalman filter to obtain the best estimates in the presence of differing noise models. These estimates are used to correct for gyroscope drift and also provide the information necessary to implement optimal attitude control with active damping of the flexural motion. (Author)

A82-26783

UNIFORM REAL-VARIABLE ASYMPTOTIC APPROXIMATIONS FOR VIBRATIONS OF A ROTATING FLEXIBLE ROD

W. D. LAKIN and A. NACHMAN (Old Dominion University, Norfolk, VA) SIAM Journal on Applied Mathematics, vol. 42, Feb. 1982, p. 77-85. refs

Asymptotic approximations to solutions of the equation for vibrations of a rapidly rotating flexible rod are derived, which are uniformly valid on intervals containing a turning point of the equation. The approximations involve only functions of a real variable, eliminating the need to go into the complex plane to cross a turning point. The uniform approximations are used to study the eigenvalue problem for transverse vibrations of a rotating spoke. (Author)

A82-27514

METHODS FOR THE DESIGN OF FLIGHT-VEHICLE CONTROL SYSTEMS [METODY PROEKTIROVANIYA SISTEM UPRAVLENIYA LETATEL'NYMI APPARATAMI]

IU. I. TOPCHEEV and A. I. KISELEV In: Scientific lectures on aviation and astronautics 1980. Moscow, Izdatel'stvo Nauka, 1981, p. 141-160. In Russian. refs

A brief survey of methods for the design of flight-vehicle control and stabilization is presented. Attention is given to methods involving mathematical models of multilevel systems, models of human-operator behavior, and methods for the identification and synthesis of complex dynamic systems on the basis of state estimation. The application of high-precision stabilization systems to solve problems of space navigation, geodesy, and communication is considered. B.J.

N82-10802# Engins Matra, Velizy (France).

ANALYSIS OF TECHNIQUES FOR THE REDUCTION OF MODELS. NONLINEAR FILTERING [ANALYSE DES TECHNIQUES DE REDUCTION DE MODELES: FILTRAGE NON-LINEAIRE]

C. GUEDON and B. GOVIN 1980 96 p refs In FRENCH
Avail: NTIS HC A05/MF A01

Diverse techniques which can be applied to particular systems, the equations of which were well adapted to the description of large satellite structures, are critically reviewed. These include aggregation, participation in optimal control, the modal gains technique, impulsion responses, and tests for observability and commandability. The effect of spillover on calculations is also considered. The technique that seems the most promising is the one which depends on modal contributions to impulsion responses, because it comprehends a physical interpretation of truncation phenomena and it is well adapted to an algorithmic treatment.

Author (ESA)

N82-11081# Purdue Univ., Lafayette, Ind. School of Aeronautics and Astronautics.

CONTROL DESIGN OF FLEXIBLE SPACECRAFT

R. E. SKELTON In AGARD Theory and Appl. of Optimal Control in Aerospace Systems 28 p Jul. 1981 refs
Avail: NTIS HC A13/MF A01

When compared to other large scale systems, flexible spacecraft have some peculiarities which can make control more difficult. Emphasis is placed upon the time domain and suboptimal linear quadratic gaussian (LOG) methods, with special attention given to the effects of modeling errors. These effects are discussed in light of the model reduction problem, stability, and control design. Stability, controllability and observability computations are reduced to their simplest form possible to provide insight and to facilitate the location of sensors and actuators. The techniques of modal cost analysis are used to identify the critical parameters and the critical models of the structure. In the final stage of design, component cost analysis reveals which states of the optimal dynamical controller should be deleted to produce a reduced controller which is compatible with the on-line computer software limitations. T.M.

N82-11098*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

NONPARAMETRIC IDENTIFICATION OF A CLASS OF NONLINEAR CLOSE-COUPLED DYNAMIC SYSTEMS

F. E. UDWADIA and C. P. KUO 1 Oct. 1981 76 p refs
(NASA-CR-164948; JPL-PUB-81-48) Avail: NTIS HC A05/MF A01 CSCL 22D

A nonparametric identification technique for the identification of close coupled dynamic systems with arbitrary memoryless nonlinearities is presented. The method utilizes noisy recorded data (acceleration, velocity and displacement) to identify the restoring forces in the system. The masses in the system are assumed to be known (or fairly well estimated from the design drawings). The restoring forces are expanded in a series of orthogonal polynomials and the coefficients of these polynomial expansions are obtained by using least square fit method. A

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particularly simple and computationally efficient method is proposed for dealing with separable restoring forces. The identified results are found to be relatively insensitive to measurement noise. An analysis of the effects of measurement noise on the quality of the estimates is given. The computations are shown to be relatively quick (when compared say to the Wiener identification method) and the core storage required relatively small, making the method suitable for onboard identification of large space structures.

B.W.

N82-11099*# Rensselaer Polytechnic Inst., Troy, N. Y.
PARAMETER ESTIMATION OF LARGE FLEXIBLE AEROSPACE STRUCTURES WITH APPLICATION TO THE CONTROL OF THE MAYPOLE DEPLOYABLE REFLECTOR

M. J. BALAS 6 Nov. 1981 20 p refs

(Contract NAG1-171)

(NASA-CR-164971) Avail: NTIS HC A02/MF A01 CSCL 22B

Systems such as the Maypole deployable reflector have a distributed parameter nature. The flexible column and hoop structure and the circular antenna of 30-100 meter diameter which it supports are described by partial, rather than ordinary, differential equations. Progress completed in reduced order modelling and controller design and digital parameter estimation and control is summarized. Topics covered include depolyment and on-orbit operation; quasi-static (steady state) operation; dynamic distributed parameter system; autoregressive moving average identification; frequency domain procedures; direct or implicit active control; adaptive observers; parameter estimation using a linear reinforcement learning factor; feedback control; and reduced order modeling for nonlinear systems.

A.R.H.

N82-11100*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.

ON THE SHAPE AND ORIENTATION CONTROL OF AN ORBITING SHALLOW SPHERICAL SHELL STRUCTURE

P. M. BAINUM and A. S. S. R. REDDY 9 Jul. 1981 7 p refs
Presented at the Joint IFAC/ESA Symp. on Automatic Control in Space, Noordwijkerhout, The Netherlands, 5-9 Jul. 1981

(Contract NSG-1414)

(NASA-CR-164970) Avail: NTIS HC A02/MF A01 CSCL 22B

A proposed method for controlling the shape and orientation of very large shallow dish type receiver/reflectors to be used in communication, radiometry and in electronic orbital based mail systems involves connecting a rigid light weight dumbbell with heavy tip masses to the shell at its apex by a spring loaded double gimbaled joint with damping. To completely damp the system transient motion in all of the important lower frequency modes, an active control system is required. A mathematical model is extended to include the effects of point actuators located at preselected positions on the shell surface. The formulation of the uncontrolled dynamics assumes an a priori knowledge of the frequencies of all the elastic modes to be incorporated within the system model. As an example, three rigid body modes and six elastic modes are included in the model and six actuators are assumed, none of which lies on a nodal line or circle.

A.R.H.

N82-12096*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.

THE DYNAMICS AND CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES Semiannual Status Report, 16 May - 15 Nov. 1981

P. M. BAINUM, R. KRISHNA, V. K. KUMAR, and A. S. S. R. REDDY 15 Nov. 1981 26 p refs

(Contract NSG-1414)

(NASA-CR-164982) Avail: NTIS HC A03/MF A01 CSCL 22B

The dynamics and attitude and shape control of very large, inherently flexible spacecraft systems were investigated. Increasingly more complex examples were examined, beginning with a uniform free-free beam, next a free-free uniform plate/platform and finally by considering a thin shallow spherical shell structure in orbit. The effects devices were modeled. For given sets of assumed actuator locations, the controllability of these systems was first established. Control laws for each of the

actuators were developed based on decoupling techniques (including distributed modal control) pole placement algorithms and a application of the linear regulator problem for optical control theory.

B.W.

N82-13158 Purdue Univ., Lafayette, Ind.
CONTROL DESIGN FOR PARAMETER SENSITIVITY REDUCTION IN LINEAR REGULATORS: APPLICATION TO LARGE FLEXIBLE SPACE STRUCTURES Ph.D. Thesis

R. YEDAVALLI 1981 236 p

Avail: Univ. Microfilms Order No. 8123729

The problem of control design for linear systems having parameter uncertainty is addressed from two viewpoint: viewpoints to minimize or reduce the trajectory and/or performance cost dispersion from the nominal values in the presence of small variations in the system parameters, and to maintain some optimal or satisfactory level of performance in the presence of small variations in the system parameters subject to model/controller truncation. It is shown that the minimization of a modified performance index that includes a quadratic term of trajectory sensitivity (state, output or control) subject to the augmented sensitivity system dynamics causes reduction not only in trajectory sensitivity but also in cost sensitivity. The control of large flexible space structures where there is large uncertainty associated with the modal data and constraints on the controller order, model reduction is required before linear multivariable theory can be applied to design controllers. The preliminary step taken in this direction is to use the concepts of open loop 'modal cost analysis' to derive explicit analytical formulae for 'modal costs' and 'parameter costs' for specific performance objectives.

Dissert. Abstr.

N82-13166*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SHAPE DETERMINATION AND CONTROL FOR LARGE SPACE STRUCTURES

C. J. WEEKS 1 Oct. 1981 175 p refs

(Contract NAS7-100)

(JPL-PUB-81-71) Avail: NTIS HC A08/MF A01 CSCL 22B

An integral operator approach is used to derive solutions to static shape determination and control problems associated with large space structures. Problem assumptions include a linear self-adjoint system model, observations and control forces at discrete points, and performance criteria for the comparison of estimates or control forms. Results are illustrated by simulations in the one dimensional case with a flexible beam model, and in the multidimensional case with a finite model of a large space antenna. Modal expansions for terms in the solution algorithms are presented, using modes from the static or associated dynamic mode. These expansions provide approximated solutions in the event that a used form analytical solution to the system boundary value problem is not available.

Author

N82-13168 Stanford Univ., Calif.

ON THE MODELING AND CONTROL OF FLEXIBLE SPACE STRUCTURES Ph.D. Thesis

B. WIE 1981 216 p

Avail: Univ. Microfilms Order No. 8124171

The development of generic models of flexible space structures for control analysis and synthesis is discussed. Transfer functions with exact poles and zeros are derived for some simple generic models such as bars, beams, membranes, toroids, a triangular truss, and a triangular frame. In the first two models (bars and beams), transfer functions for the separated actuator and sensor pairs are also discussed. A comparison is made between the two lumped parameter transfer functions obtained by (1) truncating the exact partial fraction expansion, and (2) truncating the exact infinite product expansion of an infinite dimensional transfer function. The significance of near pole zero cancellations and inherent structural damping in designing control logic for infinite dimensional systems is shown. Attitude control of flexible space structures with an infinite number of vibration modes is investigated

by using the exact infinite - dimensional transfer functions.

Dissert. Abstr.

N82-14139# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.

L-SAT STATIONKEEPING

J. J. POCHA and A. F. EDWARDS *In* ESA Spacecraft Flight Dyn. p 169-182 Aug. 1981

Avail: NTIS HC A22/MF A01; ESA, Paris FF 160 Member States, AU, CN and NO (+20% others)

The stationkeeping strategy for L-SAT is derived. The orbit perturbations that must be counteracted arise not only from natural sources such as triaxiality, solar radiation pressure, and lunisolar gravitation, but also from the spacecraft attitude control system operating in its normal and stationkeeping modes. The strategy is designed to allow for worst case conditions on a statistical basis and includes the effects of tracking and maneuver implementation errors. It provides for stationkeeping within the specified deadband with an optimum use of propellant.

Author (ESA)

N82-14147# Universite Catholique de Louvain (Belgium).

PARTITIONING METHODS FOR IDENTIFICATION AND CONTROL OF FLEXIBLE SPACECRAFT

G. CAMPION and P. Y. WILLEMS *In* ESA Spacecraft Flight Dyn. p 245-251 Aug. 1981 refs

Avail: NTIS HC A22/MF A01; ESA, Paris FF 160 Member States, AU, CN and NO (+20% others)

Results obtained in the estimation of the state vector and in the parameter identification of a linear model of Geos are presented. The sequential decision technique based on a binary quantization procedure is used. This method is tested with simulated data as well as with in-flight data provided by telemetry. Numerical results show good parameter identification, although when many have to be identified simultaneously, decision criteria must not be too severe. In-flight data from accelerometers are close to predicted values, but magnetometer data are available only for spin motion, so parameter identification is limited to preliminary steps.

Author (ESA)

N82-14667# Centre National d'Etudes Spatiales, Toulouse (France). Div. Stabilization Structures Thermique.

MODAL ANALYSIS OF STRUCTURES WITH PRESTRESS EFFECTS: APPLICATION TO FLEXIBLE SOLAR GENERATORS [ANALYSE MODELE DE STRUCTURES AVEC EFFETS DE RECONTRAINTES. APPLICATION AUX GENERATEURS SOLAIRES SOUPLES]

B. BOISSIN 20 May 1981 76 p refs *In* FRENCH (CNES-81/CT/PRT/SST/SM/178) Avail: NTIS HC A05/MF A01

A model of the dynamic behavior of a flexible solar array which is part of a satellite-borne solar generator for spacecraft power supply (4 to 10kW) is presented. Results are appropriate for solving problems of spacecraft attitude control. The array is depicted as a skin covered by solar cells. Modal characterization of prestressed structures is explained for the calculation of differential rigidity. The method is demonstrated for a beam loaded at each end and for a square plate loaded along two opposite sides. Results for an array which is deployed along a telescoping mast are shown.

Author (ESA)

N82-16146# Communications Research Centre, Ottawa (Ontario). Space Technology and Applications Branch.

NATURAL MODES AND REAL MODAL VARIABLES FOR FLEXIBLE SPACECRAFT

F. R. VIGNERON Nov. 1981 23 p refs (CRC-1348) Avail: NTIS HC A02/MF A01

A natural model transformation theory which is applicable to flexible spacecraft with damping and gyroscopic forces is described. The theory is arranged into a form which is a generalization of the classical normal modes transformation theory. Modal differential equations are given in terms of real-value scalars. Block diagrams in the time and Laplace transform domains demonstrate the feed-forward and second-order filter characteristics of the structure

of the equations. Results for a single-axis flexible dynamics example are compared with earlier published results to show the correlation with the classical normal modes transformation theory. B.W.

N82-16165*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ADAPTIVE CONTROL SYSTEM FOR LARGE ANNULAR MOMENTUM CONTROL DEVICE

R. C. MONTGOMERY and C. R. JOHNSON, JR. (Virginia Polytechnic Inst. and State Univ.) *In* its The Microwave Radiometer

Spacecraft p 169-187 Dec. 1981 refs

Avail: NTIS HC A11/MF A01 CSCL 22B

A dual momentum vector control concept, consisting of two counterrotating rings (each designated as an annular momentum control device), was studied for pointing and slewing control of large spacecraft. In a disturbance free space environment, the concept provides for three axis pointing and slewing capabilities while requiring no expendables. The approach utilizes two large diameter counterrotating rings or wheels suspended magnetically in many race supports distributed around the antenna structure. When the magnets are energized, attracting the two wheels, the resulting gyroscopic torque produces a rate along the appropriate axis. Roll control is provided by alternating the radiative rotational velocity of the two wheels. Wheels with diameters of 500 to 800 m and with sufficient momentum storage capability require rims only a few centimeters thick. The wheels are extremely flexible; therefore, it is necessary to account for the distributed nature of the rings in the design of the bearing controllers. Also, ring behavior is unpredictably sensitive to ring temperature, spin rate, manufacturing imperfections, and other variables. An adaptive control system designed to handle these problems is described.

J.M.S.

N82-16167*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

BOOTLACE CATENARY CONCEPT FOR ANTENNA SHAPE CONTROL

J. H. RAMSEY (Kentron International, Inc.) and R. L. WRIGHT *In* its The Microwave Radiometer Spacecraft p 205-213 Dec. 1981 refs

Avail: NTIS HC A11/MF A01 CSCL 22B

A preliminary design of the microwave radiometer spacecraft (MRS) using the bootlace catenary shaping concept was developed. The application of this radically different design for shape control of the antenna membrane was assessed and possible sources of inaccuracies and errors were investigated.

Author

N82-16168# Control Dynamics Co., Huntsville, Ala.

ACOSS NINE (ACTIVE CONTROL OF SPACE STRUCTURES) Final Technical Report, 1 Apr. 1980 - 1 Apr. 1981

S. M. SELTZER, H. E. WORLEY, B. A. ASNER, JR., and D. D. SILJAK Griffiss AFB, N.Y. RADC Sep. 1981 132 p refs (Contract F30602-80-C-0177; ARPA ORDER 3653; AF PROJ. C654)

(AD-A106686; RADC-TR-81-240) Avail: NTIS HC A07/MF A01 CSCL 22B

This is the Control Dynamics Final Report on the analysis and evaluation of Large Space Structures. The research was primarily aimed at mathematical model development and control system analysis and design tool development.

Author (GRA)

N82-16169# Control Dynamics Co., Huntsville, Ala.

ACOSS SEVEN (ACTIVE CONTROL OF SPACE STRUCTURES) Final Technical Report, 17 Apr. - 19 Dec. 1980

J. R. SESAK Griffiss AFB, N.Y. RADC Sep. 1981 103 p refs

(Contract F30602-80-C-0164; ARPA ORDER 3654; AF PROJ. C654)

(AD-A106687; RADC-TR-81-241) Avail: NTIS HC A06/MF A01 CSCL 22B

This report covers active structural control theory extensions, simulations, and demonstration test planning as they relate to precision control of large space systems. Theory material includes

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a filter accommodation technique for stabilizing higher modes without degrading controlled mode performance, Liapunov stability analysis, and disturbance accommodation techniques for systems where damping alone cannot meet requirements. Author (GRA)

N82-17057* # Clarkson Coll. of Technology, Potsdam, N.Y. Dept. of Electrical and Computer Engineering.

ATTITUDE CONTROL OF THE SPACE CONSTRUCTION BASE: A MODULAR APPROACH

D. A. OCONNOR /in Alabama Univ. in Huntsville The 1981 NASA/ASEE Summer Fac. Fellowship Program 35 p Jan. 1982

Avail: NTIS HC A25/MF A01 CSCL 22B

A planar model of a space base and one module is considered. For this simplified system, a feedback controller which is compatible with the modular construction method is described. The systems dynamics are decomposed into two parts corresponding to base and module. The information structure of the problem is non-classical in that not all system information is supplied to each controller. The base controller is designed to accommodate structural changes that occur as the module is added and the module controller is designed to regulate its own states and follow commands from the base. Overall stability of the system is checked by Liapunov analysis and controller effectiveness is verified by computer simulation. J.D.H.

N82-17243* # Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.

ON THE SHAPE AND ORIENTATION CONTROL OF AN ORBITING SHALLOW SPHERICAL SHELL STRUCTURE

P. M. BAINUM and A. S. S. R. REDDY 9 Jul. 1982 11 p refs Proposed for presentation at the Joint IFAC/ESA Symp. on Automatic Control in Space, Noordwijkerhout, Netherlands, 5-9 Jul. 1982

(Contract NSG-1414)

(NASA-CR-168420) Avail: NTIS HC A02/MF A01 CSCL 22A

The dynamics of orbiting shallow flexible spherical shell structures under the influence of control actuators was studied. Control laws are developed to provide both attitude and shape control of the structure. The elastic modal frequencies for the fundamental and lower modes are closely grouped due to the effect of the shell curvature. The shell is gravity stabilized by a spring loaded dumbbell type damper attached at its apex. Control laws are developed based on the pole clustering techniques. Savings in fuel consumption can be realized by using the hybrid shell dumbbell system together with point actuators. It is indicated that instability may result by not including the orbital and first order gravity gradient effects in the plant prior to control law design. E.A.K.

N82-17255* # Jet Propulsion Lab., California Inst. of Tech., Pasadena.

CONTROL SYSTEM DESIGN FOR THE LARGE SPACE SYSTEMS TECHNOLOGY REFERENCE PLATFORM

R. S. EDMUNDS 15 Jan. 1982 112 p refs

(Contract NAS7-100)

(NASA-CR-168426; JPL-PUB-81-77) Avail: NTIS HC A06/MF A01 CSCL 22B

Structural models and classical frequency domain control system designs were developed for the large space systems technology (LSST) reference platform which consists of a central bus structure, solar panels, and platform arms on which a variety of experiments may be mounted. It is shown that operation of multiple independently articulated payloads on a single platform presents major problems when subarc second pointing stability is required. Experiment compatibility will be an important operational consideration for systems of this type. A.R.H.

N82-17522* # Grumman Aerospace Corp., Bethpage, N.Y. **AN INVESTIGATION OF DYNAMIC-ANALYSIS METHODS FOR VARIABLE-GEOMETRY STRUCTURES Final Report**

F. AUSTIN Dec. 1980 280 p refs

(Contract NAS9-15895)

(NASA-CR-167498; CSS-SSS-RP002) Avail: NTIS HC A13/MF A01 CSCL 20K

Selected space structure configurations were reviewed in order to define dynamic analysis problems associated with variable geometry. The dynamics of a beam being constructed from a flexible base and the relocation of the completed beam by rotating the remote manipulator system about the shoulder joint were selected. Equations of motion were formulated in physical coordinates for both of these problems, and FORTRAN programs were developed to generate solutions by numerically integrating the equations. These solutions served as a standard of comparison to gauge the accuracy of approximate solution techniques that were developed and studied. Good control was achieved in both problems. Unstable control system coupling with the system flexibility did not occur. An approximate method was developed for each problem to enable the analyst to investigate variable geometry effects during a short time span using standard fixed geometry programs such as NASTRAN. The average angle and average length techniques are discussed. A.R.H.

N82-18283* # Idaho Univ., Moscow. Dept. of Engineering Science.

VIBRATION DAMPING CHARACTERISTICS OF GRAPHITE/EPOXY COMPOSITES FOR LARGE SPACE STRUCTURES

R. F. GIBSON /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 123-132 Mar. 1982 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

Limited data on extensional and flexural damping of small specimens of graphite/epoxy and unreinforced epoxy resin were obtained. Flexural damping was measured using a forced vibration technique based on resonant flexural vibration of shaker excited double cantilever specimens. Extensional damping was measured by subjecting similar specimens to low frequency sinusoidal oscillation in a servohydraulic tensile testing machine while plotting load versus extensional strain. Damping was found to vary slowly and continuously over the frequency range 0.01 - 1000 Hz, and no drastic transitions were observed. Composite damping was found to be less than neat resin damping. Comparison of small specimen damping values with assembled column damping values seems to indicate that, for those materials, material damping is more important than joint damping. The data reported was limited not by the test apparatus, but by signal conditioning and data acquisition. It is believed that filtering of the strain gage signals and the use of digital storage with slow playback will make it possible to extend the frequency and amplitude ranges significantly. M.D.K.

N82-18284* # California Inst. of Tech., Pasadena. Div. of Engineering.

THE POTENTIAL OF NONPERIODIC TRUSS STRUCTURES FOR SPACE APPLICATIONS

K. C. PERK (Lockheed Palo Alto Research Lab.) and J. M. WINGER /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 133-143 Mar. 1982

Avail: NTIS HC A19/MF A01 CSCL 22B

In order to assess the dynamic characteristics of truss structures made of the nonperiodic lattices, a cantilever truss beam was analyzed for vibrations. In addition, three additional lattice configurations were also constructed along with two beams made of tetrahedrons. The relative frequency variations of the six cantilever truss beams for their first mode were examined. To make the comparison meaningful, the beam length, the number of lattice joints and the total weight were chosen to be identical within 2 percent differences. The frequencies of the four nonperiodic truss beams varied over 60 percent while those of the two beams of tetrahedron lattices only about 13 percent. Such wide frequency variations of the proposed nonperiodic truss beams

indicate that the introduction of nonperiodic lattices could be effectively used to improve the controllability of steady state vibration as well as improved wave dispersion characteristics.

T.M.

N82-18293*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

LSS CONTROL TECHNOLOGY

A. F. TOLIVAR /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 241-247 Mar. 1982
 Avail: NTIS HC A19/MF A01 CSCL 22B

Control for Large Space Systems is discussed. Emphasis is placed on platform control and antenna control. L.F.M.

N82-18294*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

CONTROL OF LARGE SPACE ANTENNAS: WRAP-RIB-HOOP/COLUMN

Y. H. LIN /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 249-281 Mar. 1982 refs
 Avail: NTIS HC A19/MF A01 CSCL 22B

Control work for large space antenna systems is discussed. Included are the wrap-rib and hoop/column antenna concepts for communications and radiometry. L.F.M.

N82-18295*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SPATIAL, HIGH-ACCURACY, POSITIONING-ENCODING SENSOR (SHAPES) FOR LARGE SPACE SYSTEM CONTROL APPLICATIONS

J. M. MCLAUCHLAN /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 283-296 Mar. 1982
 Avail: NTIS HC A19/MF A01 CSCL 22B

The Spatial, High-Accuracy, Position-Encoding Sensor is a controls sensor suitable for the determination of the static shape and vibrational motion of large space structures and similar systems and for the determination of position and velocity in rendezvous and docking. It uses a combination of electro-optical techniques to measure the three-dimensional coordinates distributed over the structure at reading rates high compared to the rates at which the coordinates are changing. The technical approach is that of measuring the distance to and the direction of points on the structure from a single sensor head. Many points can be measured simultaneously from a single head without significantly increasing the complexity of the system. L.F.M.

N82-18296*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

CONTROL TECHNOLOGY DEVELOPMENT

D. B. SCHAECHTER /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 297-311 Mar. 1982 refs
 Avail: NTIS HC A19/MF A01 CSCL 22B

The main objectives of the control technology development task are given in the slide below. The first is to develop control design techniques based on flexible structural models, rather than simple rigid-body models. Since large space structures are distributed parameter systems, a new degree of freedom, that of sensor/actuator placement, may be exercised for improving control system performance. Another characteristic of large space structures is numerous oscillatory modes within the control bandwidth. Reduced-order controller design models must be developed which produce stable closed-loop systems when combined with the full-order system. Since the date of an actual large-space-structure flight is rapidly approaching, it is vitally important that theoretical developments are tested in actual hardware. Experimental verification is a vital counterpart of all current theoretical developments. L.F.M.

N82-18297*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

LSS REFERENCE PLATFORM CONTROL

R. S. EDMUNDS /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 313-333 Mar. 1982
 Avail: NTIS HC A19/MF A01 CSCL 22B

The long range objective of this task is to develop basic technology in the design, mechanization, and analysis of control systems for large flexible space structures. The focus of the FY'81 platform control effort was on the pointing control problems associated with multiple independently controlled experiment packages operating simultaneously on a single platform. Particular emphasis was placed on obtaining a quantitative comparison of controller performance with and without base motion compensation. L.F.M.

N82-18299*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

A DISTURBANCE ISOLATION CONTROLLER FOR THE SOLAR ELECTRIC PROPULSION SYSTEM FLIGHT EXPERIMENT

H. B. WAITES /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 345-361 Mar. 1982 refs
 Avail: NTIS HC A19/MF A01 CSCL 22B

A disturbance isolation controller (DIC) is developed for a simplified model of the solar electric propulsion system (SEPS) flight experiment which consists of a rigid Sperry gimbal torquer (AGS) mounted to a rigid orbiter and the SEPS solar array (rigid) end mounted to the AGS. The main purpose of the DIC is to reduce the effects of orbiter disturbances which are transmitted to the flight experiment. The DIC uses an observer, which does not require the direct measurement of the plant inputs, to obtain estimates of the plant states and the rate of the plant states. The state and rate of state information is used to design a controller which isolates disturbances from specified segments of the plant, and for the flight experiment, the isolated segment is the SEPS solar array. S.L.

N82-18300*# Bendix Corp., Teterboro, N. J. Test Systems Div. MODULAR ATTITUDE CONTROL OF A LARGE SPACE PLATFORM

F. D. CHICHESTER /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 363-370 Mar. 1982 refs
 Avail: NTIS HC A19/MF A01 CSCL 22B

The modular attitude control of a large space platform is studied using a three axis five body model of a flexible spacecraft. Three degree of freedom hinges are considered. A three axis four body model of a truss and a three axis ten body model of a space platform are presented. A state variable rotational dynamics model and a multilevel state variable model are shown. A decomposed performance index and decomposed Hamiltonian are also presented. A subproblem hierarchy for hybrid multilevel LQR attitude control of a three axis model is described. S.L.

N82-18301*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

SYSTEMS IDENTIFICATION TECHNOLOGY DEVELOPMENT FOR LARGE SPACE SYSTEMS

E. S. ARMSTRONG /in its Large Space Systems Technol., 1981 p 371-374 Mar. 1982 refs
 Avail: NTIS HC A19/MF A01 CSCL 22B

A methodology for synthesizing systems identification, both parameter and state, estimation and related control schemes for flexible aerospace structures is developed with emphasis on the Maypole hoop column antenna as a real world application. Modeling studies of the Maypole cable hoop membrane type antenna are conducted using a transfer matrix numerical analysis approach. This methodology was chosen as particularly well suited for handling a large number of antenna configurations of a generic type. A dedicated transfer matrix analysis, both by virtue of its specialization and the inherently easy compartmentalization of the formulation and numerical procedures, is significantly more efficient not only in computer time required but, more importantly, in the time needed to review and interpret the results. S.L.

04 STRUCTURAL DYNAMICS AND CONTROL

N82-18302*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

CONFIGURATIONAL AND SYSTEM REQUIREMENTS FOR CONTROL OF LARGE SPACE SYSTEMS

L. W. TAYLOR, JR. *In its Large Space Systems Technol.*, 1981 p 375-388 Mar. 1982

Avail: NTIS HC A19/MF A01 CSCL 22B

Control of large space systems, modeling, and control difficulties are discussed. Ground based analysis of spaceflight data are presented to determine structural dynamics characteristics for the purpose of revising control laws, and to trim the surface contour. Systems identification for adaptive control and automatic surface control are also considered. S.L.

N82-18303*# Honeywell Systems and Research Center, Minneapolis, Minn.

INTEGRATED CONTROLS/STRUCTURES STUDY OF ADVANCED SPACE SYSTEMS

C. S. GREENE and T. B. CUNNINGHAM *In NASA. Langley Research Center Large Space Systems Technol.*, 1981 p 389-412 Mar. 1982 refs

Avail: NTIS HC A19/MF A01

A cost tradeoff is postulated for a stiff structure utilizing minimal controls (and control expense) to point and stabilize the vehicle. Extra costs for a stiff structure are caused by weight, packaging size, etc. Likewise, a more flexible vehicle should result in reduced structural costs but increased costs associated with additional control hardware and data processing required for vibration control of the structure. This tradeoff occurs as the ratio of the control bandwidth required for the mission to the lowest (significant) bending mode of the vehicle. The cost of controlling a spacecraft for a specific mission and the same basic configuration but varying the flexibility is established. S.L.

N82-18304*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

ACTIVE CONTROL OF SPACE STRUCTURES: PROOF OF CONCEPT EXPERIMENT

J. A. BREAKWELL *In NASA. Langley Research Center Large Space Systems Technol.*, 1981 p 413-428 Mar. 1982

Avail: NTIS HC A19/MF A01 CSCL 22B

Modern control theory easily works with multiple input/multiple output systems. Two types of systems which fall into this category are flexible systems, where many measurements and several actuators are necessary to provide control over bending behavior, and articulated systems which consist of several rigid bodies connected together by pivoting connections. In this latter case, multiple controls are implemented as torquers at the joints. S.L.

N82-18310*# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.

A DYNAMIC MEASURE OF CONTROLLABILITY AND OBSERVABILITY FOR THE PLACEMENT OF ACTUATORS AND SENSORS ON LARGE SPACE STRUCTURES

W. E. VANDERVELDE and C. R. CARIGNAN Jan. 1982 55 p refs

(Contract NAG1-126)

(NASA-CR-168520; SSL-2-82) Avail: NTIS HC A04/MF A01 CSCL 22B

The degree of controllability of a large space structure is found by a four step procedure: (1) finding the minimum control energy for driving the system from a given initial state to the origin in the prescribed time; (2) finding the region of initial state which can be driven to the origin with constrained control energy and time using optimal control strategy; (3) scaling the axes so that a unit displacement in every direction is equally important to control; and (4) finding the linear measurement of the weighted 'volume' of the ellipsoid in the equicontrol space. For observability, the error covariance must be reduced toward zero using measurements optimally, and the criterion must be standardized by the magnitude of tolerable errors. The results obtained using these methods are applied to the vibration modes of a free-free beam. A.R.H.

N82-18313# TRW Defense and Space Systems Group, Redondo Beach, Calif.

ACROSS EIGHT (ACTIVE CONTROL OF SPACE STRUCTURES), PHASE 2 Final Technical Report, May 1980 - Apr. 1981

R. P. IWENS, R. J. BENHABIB, and F. C. TUNG Griffiss AFB, N.Y. RADC Sep. 1981 184 p refs

(Contract F30602-80-C-0198; AF PROJ. C654; ARPA ORDER 3654)

(AD-A108629; TRW-36296-6001-UT-00-PH-2; RADC-TR-81-242)

Avail: NTIS HC A09/MF A01 CSCL 13A

This effort addresses three areas of active structure control/vibration control: (1) Stability ensuring designs in the presence of modal truncation/inaccurate structural models using a method based on the positivity of operators; (2) On-orbit parameter identification using the maximum likelihood method; and (3) Trade-offs between model reference adaptive control and fixed gain control with and without on-orbit parameter identification and system tuning, developed a stability ensuring design methodology which does not rely on modal truncation, has only low sensitivity to the exact knowledge of the structures model and, with some modifications, can be extended to non-linear systems. The method yields good performance, but is not necessarily optimal. The maximum likelihood method of parameter identification was studied. Parameter data collected on-orbit could be used to up-date the control model and improve performance. An alternative to explicit parameter identification and subsequent system tuning is direct adaptive control. Trade-offs between parameter identification and tuning versus adaptive controls were coordinated and the results are presented. Author (GRA)

N82-19261*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SURFACE MEASUREMENT SYSTEM DEVELOPMENT

M. BERDAHL *In NASA. Langley Research Center Large Space Systems Technol.*, Pt. 2, 1981 p 479-490 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The development of an optical system designed to satisfy the requirements of early deployable concepts such as the LMSC offset wrap rib antenna is reported. The system is relatively lightweight, will measure distance to several targets, and provide data in engineering units in real time. Accuracy of measurements is such that use of the system will permit evaluation of surface quality of large parabolic antenna dishes. Operation of the system was conceptually proven. T.M.

N82-19271*# TRW Defense and Space Systems Group, Redondo Beach, Calif.

CONCEPTED DESIGN OF A SURFACE MEASUREMENT SYSTEM FOR LARGE DEPLOYABLE SPACE ANTENNAS

R. S. NEISWANDER *In NASA. Langley Research Center Large Space Systems Technol.*, Pt. 2, 1981 p 631-640 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The sensor system is in essence a point design, specifically interfacing with the Harris, Inc., 1000 meter deployable mesh communication antenna. The design can, without large modification, be adapted to other large deployable antennas such as the Lockheed Wrap-rib, the General Dynamics Precision Erectable Truss and the TRW Advanced Sunflower antennas. Measurements are optical displacements. The elements of the system are a central cluster of receivers near the apex of the antenna and active bright targets at the antenna. The cluster defines a single coordinate frame from which all surface positions are referenced. The receivers continuously observe an extended array of sample points located throughout the reflecting surface and its supporting structure. For the Harris antenna, the surface samples are at the mesh gore lines and at the supporting hoop. Output data is in real-time, compatible with on-board processing and active control of antenna figure. Lifetime of the system is at least 10 years continuous operation in space. T.M.

N82-19272*# Barnes Engineering Co., Stamford, Conn.
ELECTRO-OPTICAL SYSTEM FOR REMOTE POSITION MEASUREMENTS IN REAL TIME
 P. W. COLLYER, S. C. SPIELBERGER, and K. A. WARD *In* NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 641-656 Mar. 1982 refs
 Avail: NTIS HC A21/MF A01 CSCL 22B

The development of an electro-optic position sensing system usable for Large Space Systems applications is described. A form of autocollimation was selected as the best overall technology, and a brassboard model was fabricated and tested. L.F.M.

N82-19281*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ATTITUDE CONTROL SUBSYSTEM STUDY FOR THE LAND MOBILE SATELLITE SYSTEM SPACECRAFT
 A. F. TOLIVAR *In* NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 821-839 Mar. 1982
 Avail: NTIS HC A21/MF A01 CSCL 22B

This Attitude Control Subsystem study applies the generic antenna control technology to the specific requirements of the Land Mobile Satellite System mission and defines suitable attitude control subsystem designs for both the wrap/rib and hoop/column antenna configurations. The technology developments required to establish technology readiness by 1987 are also identified. L.F.M.

N82-19285*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
LARGE SPACE SHUTTLE FLIGHT EXPERIMENT
 L. M. JENKINS *In* NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 893-909 Mar. 1982
 Avail: NTIS HC A21/MF A01 CSCL 22B

It appears practical to challenge the Orbiter DAP with a large, attached structure. The definition of this capability is a fundamental step in the development of nearly all large space systems currently under consideration. Experiment features may be incorporated that apply to control systems for large space systems such as modal damping devices. In a relatively simple deployable structure, the correlation of flight test results with ground test and analysis should provide a basis for extrapolation to more complex structures. Initial experiment concepts will provide a starting point for the examination of antenna feed mast requirements with the objective changing the design to produce a representative test article. Correlation of construction operations with ground simulations will provide for better task and time-line definition. EVA needs to be a direct benefit to the conduct of the experiment. Early consideration of safety issues is a precaution against defining an unacceptable experiment concept. Integration of many objectives seems feasible and is generally perceived as the only way to justify a relatively expensive experiment. L.F.M.

N82-19553 Alabama Univ., Huntsville.
DYNAMICS OF A CHAIN OF FLEXIBLE BODIES Ph.D. Thesis
 R. P. SINGH 1981 134 p
 Avail: Univ. Microfilms Order No. 8128324

A mathematical modeling technique is developed for a space structure idealized as a collection of flexible bodies in a chain configuration. The methodology employed in the derivation does not require the presence of a rigid body in the chain. The contiguous bodies are permitted to undergo large relative rotations. The Lagrange's form of D'Alembert's principle is adopted to derive the equations of motion. The mathematical foundations of the quasicordinates are explored and it is shown that they emerge naturally from a variational principle. A floating reference frame called the Tisserand frame or the mean axis frame is selected for the dynamic analysis. It is shown that the Tisserand frame follows the deformable body in an optimal manner. This frame has a well defined motion in an inertial reference frame and is suitable for use in conjunction with linear structural theory. Dissert. Abstr.

N82-20208# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SPACECRAFT POINTING AND POSITION CONTROL
 P. P. VANDENBROEK, ed. and S. Z. SZIRMAY, ed. Nov. 1981 255 p refs
 (AGARD-AG-260; ISBN-92-835-1408-4; AD-A111405) Avail: NTIS HC A12/MF A01

Recent developments and state-of-the-art technologies were examined in the following areas: attitude control and instrument pointing, orbit determination and control, and flexible satellite control. Emphasis is placed on the stationkeeping of synchronous communication satellites and on satellite attitude control. Control moment devices are also discussed.

N82-20209# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
ATTITUDE CONTROL OF GEOSTATIONARY SATELLITES WITH DOUBLE GIMBALED MOMENTUM WHEELS
 G. SCHULZ and T. LANGE *In* AGARD Spacecraft Pointing and Position Control 25 p Nov. 1981 refs
 Avail: NTIS HC A12/MF A01

Conventional control methods are generalized using state vector feedback design procedures. Alternatively, a decoupled control method using a nondiagonal inertia tensor was derived. These are confronted to modern control theory design method with observer, where especially the insensitivity with respect to variants of the moments of inertia was demonstrated. Author

N82-20210# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
ANALYSIS AND EXPERIMENTAL VERIFICATION OF THE NUTATION OF A SATELLITE EQUIPPED WITH MAGNETIC BEARING MOMENTUM WHEELS
 C. ROUYER (SNIA, Les Mureaux, France), G. HEIMBOLT, and T. LANGE *In* AGARD Spacecraft Pointing and Position Control 19 p Nov. 1981 refs
 Avail: NTIS HC A12/MF A01

The problem of the nutation divergence of a 3 axis stabilized satellite equipped with hydrodynamic bearing momentum wheels is discussed. The magnetic bearing momentum wheels, having a relatively low transverse rigidity and dissipating energy in the rotor (due to eddy currents), are likely to present an inconvenience of the same nature, if not of the same magnitude. A physical explanation of the phenomenon is given. The results of tests carried out on an air-bearing table are presented and it is shown that phenomenon cannot be detected on a satellite of the INTELSTAT size. T.M.

N82-20214# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
GEOSTATIONARY COMMUNICATION SATELLITE CONTROL
 L. FLOOK and J. J. POCHA *In* AGARD Spacecraft Pointing and Position Control 11 p Nov. 1981
 Avail: NTIS HC A12/MF A01

The requirements for the control of the position and attitude of geostationary communications satellites were examined and some of the principle system parameters and options available are outlined. A number of current systems are compared and the principal limitations of their performance are discussed. The overall communication system trends are indicated and the effect of these upon the design of both attitude and position control is indicated. Author

N82-20216# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
DIGITAL ATTITUDE AND ORBIT CONTROL ELECTRONICS FOR LONG-LIFE COMMUNICATION SATELLITES
 M. WLAKA *In* AGARD Spacecraft Pointing and Position Control 7 p Nov. 1981 refs Sponsored in part by DFVLR-BPT
 Avail: NTIS HC A12/MF A01

A modular cost and time efficient data processing system which has found several applications in space projects such as the Spacelab Instrument Pointing System (IPS) and the Microwave

04 STRUCTURAL DYNAMICS AND CONTROL

Remote Sensing Experiment (MRSE) is described. The requirement for performing complicated control algorithms for attitude and orbit control (AOC) and the desire to use standardized on-board electronics led to the development of the modular, microprocessor based data handling system which consists of a 16 bit-processor, a memory block, and various input/output modules and has the following special features: low weight; small volume; and low power consumption achieved by using multilayer boards and flat-pack CMOS chips. The stringent reliability requirements for long-life satellites led to a high degree of redundancy and cross-strapping capability within the system. The described on-board data processing system provides the possibility of writing programs in PEARL which is ideally suited for realtime applications in the field of automatic attitude control. M.D.K.

N82-20218*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

A MULTILEVEL CONTROL APPROACH FOR A MODULAR STRUCTURED SPACE PLATFORM

F. D. CHICHESTER (Bendix Corp., Teterboro, N.J.) and M. T. BORELLI /in AGARD Spacecraft Pointing and Position Control 10 p Nov. 1981 refs

Avail: NTIS HC A12/MF A01 CSCL 22B

A three axis mathematical representation of a modular assembled space platform consisting of interconnected discrete masses, including a deployable truss module, was derived for digital computer simulation. The platform attitude control system as developed to provide multilevel control utilizing the Gauss-Seidel second level formulation along with an extended form of linear quadratic regulator techniques. The objectives of the multilevel control are to decouple the space platform's spatial axes and to accommodate the modification of the platform's configuration for each of the decoupled axes. Author

N82-20219# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.

DYNAMIC CONTROL OF LARGE SPACECRAFT: A SURVEY OF TECHNIQUES

R. C. ROGERS and M. BURTON /in AGARD Spacecraft Pointing and Position Control 11 p Nov. 1981 refs

Avail: NTIS HC A12/MF A01

A number of techniques for the dynamic control of large spacecraft are discussed. The main problems identified are the high order of the system and model accuracy. One basic approach to design a controller for a low order model obtained by truncating modes from the system model is discussed. This may lead to instability problems due to interaction with unmodelled modes. A number of techniques are discussed which aim to avoid or overcome these problems. An alternative approach to controller design aims at ensuring stability in the presence of modelling errors and truncated modes. In the simplest case this involves direct output feedback. A technique which enables a dynamic approach to be used is also discussed although it uses rate measurement and can therefore only be applied to vibration control. A brief comparison of the various control approaches applied to the control of a large platform is presented. Author

N82-20220# Lockheed Missiles and Space Co., Palo Alto, Calif. **MODELING, CONTROL AND SYSTEM IDENTIFICATION METHODS FOR FLEXIBLE STRUCTURES**

N. K. GUPTA (Integrated Systems, Inc., Palo Alto, Calif.), M. G. LYONS (Integrated Systems, Inc., Palo Alto, Calif.), J. N. AUBRUN, and G. MARGULIES /in AGARD Spacecraft Pointing and Position Control 41 p Nov. 1981 refs

Avail: NTIS HC A12/MF A01

Modeling, control design and system identification techniques to synthesize feedback control laws for large space structures are discussed. The theoretical background is covered. Techniques are applied to a mathematical model with complexity comparable to that of real flexible spacecraft. A tutorial description of the problem and summary of recent developments is included. The discussion is oriented towards the control design engineer. Author

N82-20221*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

CONTROL OF LARGE SPACE STRUCTURES USING ANNUAL MOMENTUM CONTROL DEVICES (AMCD'S)

S. M. JOSHI /in AGARD Spacecraft Pointing and Position Control 12 p Nov. 1981 refs

Avail: NTIS HC A12/MF A01 CSCL 22B

A controller design approach for large space structures, which proposes the use of several Annular Momentum Control Devices (AMCD's) for structural damping enhancement, and either torque actuators of AMCD's for primary attitude control, was investigated. The damping enhancement controller makes the system asymptotically stable under certain relatively simple conditions. The closed-loop stability of the system with the primary attitude controller as well as the overall controller was established. It is shown that the same AMCD's can be used for the actuation of the damping enhancement controller and the primary attitude controller. Numerical results were obtained for a finite-element model of a large, thin, completely free, flat aluminum plate.

Author

N82-20222# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).

MODERN SIMULATION TECHNIQUES IN SPACECRAFT DYNAMICS

R. STAPF, G. HEIMBOLD, and J. PULS /in AGARD Spacecraft Pointing and Position Control 27 p Nov. 1981 refs

Avail: NTIS HC A12/MF A01

For investigation of the dynamic behavior of spacecraft systems, simulations are commonly used in nearly every phase of a mission. Three hardware simulation methods are presented: a pure physical simulation method, which makes extensive use of scaling techniques in order to overcome technical and environmental difficulties is demonstrated by means of two examples; a hybrid simulation technique is presented, which allows to include the dynamic behavior of flexible appendages into a physical simulation; and finally, the possibility of implicating satellite hardware in a computer simulation by use of a three axes flight simulator is pointed out. M.D.K.

N82-20239# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.

ACROSS SIX (ACTIVE CONTROL OF SPACE STRUCTURES) Final Technical Report, 14 Feb. 1980 - 13 Feb. 1981

R. STRUNCE, K. G. LIN, D. R. HEGG, E. FOGEL, J. D. TURNER, R. K. PEARSON, G. J. KISSEL, H. M. CHUN, and N. H. MCCLANROCH Griffiss AFB, N.Y. RADC Oct. 1981 206 p refs

(Contract F30602-80-C-0096; AF PROJ. C654; ARPA ORDER 3654)

(AD-A108910; R-1454; RADC-TR-81-289) Avail: NTIS HC A10/MF A01 CSCL 22B

The research documented in this report addresses several major technical issues in vibration controller design methodologies that are of fundamental importance to control of large flexible space structures. Fundamentally important analytical and numerical results, as well as useful new insights, have been obtained on: optimality of fixed-form reduced-order compensators; full-order closed-loop stability and robustness with reduced-order controllers; prevention of control and observation spillover; active augmentation of damping, stiffness, and stability, stabilizability by output feedback control; large-angle maneuver with simultaneous vibration suppression; and possibilities for improving current controller design methodologies. GRA

05

ELECTRONICS

N82-21249# European Space Agency, Paris (France).
**SPACECRAFT DYNAMIC ANALYSIS USING CANTILEVER
 MODES OF THE APPENDAGES: AN APPLICATION TO THE
 SPACE TELESCOPE**

D. POELAERT (ESTEC, Noordwijk, Netherlands) Oct. 1981 103
 p refs
 (ESA-STR-206; ISSN-0379-4067) Avail: NTIS HC A06/MF A01;
 ESA, Paris FF 55

Spacecraft global modes are studied when the fixed base modes of the flexible appendages obtained first are equivalent to solving an implicit eigenvalue problem for a system of up to six dimensions (the number of spacecraft rigid modes). The key for performing the global dynamical analysis without having to reconsider the whole structural modeling of the appendages (by the finite element or other methods) is provided. This is useful when appendages are added, modified, or assume different orientations with respect to the spacecraft, e.g., solar arrays before and after a slew maneuver. The method produces transfer functions between forces and displacements at any two points of the spacecraft, including the flexible parts. Selection of the significant modes is based on the importance of their modal gains rather than on frequency bandwidth considerations; the errors introduced by such a modal truncation are interpreted. Author (ESA)

N82-21250*# Lockheed Engineering and Management Services
 Co., Inc., Houston, Tex.

AVIONICS TEST BED DEVELOPMENT PLAN

L. H. HARRIS, J. M. PARKS, and C. R. MURDOCK Dec. 1981
 89 p
 (Contract NAS9-15800)

(NASA-CR-167579; NAS 1.26:167579; JSC-17859;
 LEMSCO-17155A) Avail: NTIS HC A05/MF A01 CSCL 22B

A development plan for a proposed avionics test bed facility for the early investigation and evaluation of new concepts for the control of large space structures, orbiter attached flex body experiments, and orbiter enhancements is presented. A distributed data processing facility that utilizes the current laboratory resources for the test bed development is outlined. Future studies required for implementation, the management system for project control, and the baseline system configuration are defined. A background analysis of the specific hardware system for the preliminary baseline avionics test bed system is included. E.A.K.

N82-21251*# Lockheed Engineering and Management Services
 Co., Inc., Houston, Tex. Engineering Development and Integration
 Branch.

AVIONICS TEST BED DEVELOPMENT PLAN

L. H. HARRIS, J. M. PARKS, and C. R. MURDOCK Dec. 1981
 37 p
 (Contract NAS9-15800)

(NASA-CR-167580; NAS 1.26:167580; JSC-17859;
 LEMSCO-17155A-SUPPL) Avail: NTIS HC A03/MF A01 CSCL
 22B

The plan is for a facility for the early investigation and evaluation of new concepts for the control of large space structures, orbiter attached flex body experiments, and orbiter enhancements. This plan outlines a distributed data processing facility that will utilize the current JSC laboratory resources for the test bed development. The future studies required for implementation, the management system for project control, and the baseline system configuration are described. T.M.

Includes techniques for power and data distribution, antenna RF performance analysis, and communications systems.

A82-10659

**CROSS-SPECTRAL DENSITIES OF ARRAY ELEMENTS FOR
 FOLDED DIPOLE AND LOOP ANTENNAS**

T. S. M. MACLEAN, S. P. S. SAINI, and Z. BARBOZA (Birmingham,
 University, Birmingham, England) Electronics Letters, vol. 17,
 Oct. 1, 1981, p. 749-751. refs

When a loop or folded dipole antenna is placed in a noise field the resultant mean-square noise current is a function of the cross-spectral densities between the different segments of the antenna. Earlier work on the evaluation of cross-spectral densities between the collinear segments of a dipole placed in an isotropic noise field is here extended to include the parallel and orthogonal segments of rectangular loop and folded dipole antennas.

(Author)

A82-11706*# Life Systems, Inc., Cleveland, Ohio.

**ALKALINE REGENERATIVE FUEL CELL SYSTEMS FOR
 ENERGY STORAGE**

F. H. SCHUBERT (Life Systems, Inc., Cleveland, OH), M. A. REID
 (NASA, Lewis Research Center, Cleveland, OH), and R. E. MARTIN
 (United Technologies Corp., South Windsor, CT) In: Intersociety
 Energy Conversion Engineering Conference, 16th, Atlanta, GA,
 August 9-14, 1981, Proceedings. Volume 1. New York, American
 Society of Mechanical Engineers, 1981, p. 61-66. refs

A description is presented of the results of a preliminary design study of a regenerative fuel cell energy storage system for application to future low-earth orbit space missions. The high energy density storage system is based on state-of-the-art alkaline electrolyte cell technology and incorporates dedicated fuel cell and electrolysis cell modules. In addition to providing energy storage, the system can provide hydrogen and oxygen for attitude control of the satellite and for life support. During the daylight portion of the orbit the electrolysis module uses power provided by the solar array to generate H₂ and O₂ from the product water produced by the fuel cell module. The fuel cell module supplies electrical power during the dark period of the orbit. G.R.

A82-11712*# Rice Univ., Houston, Tex.

**DIRECT CONVERSION OF LIGHT TO RADIO FREQUENCY
 ENERGY**

J. W. FREEMAN and S. SIMONS (Rice University, Houston, TX)
 In: Intersociety Energy Conversion Engineering Conference, 16th,
 Atlanta, GA, August 9-14, 1981, Proceedings. Volume 1. New
 York, American Society of Mechanical Engineers, 1981, p. 95, 96.
 Research supported by the Brown Foundation of Houston
 (Contract NAG3-29)

A description is presented of the test results obtained with the latest models of the phototron. The phototron was conceived as a replacement for the high voltage solar cell-high power klystron combination for the solar power satellite concept. Physically, the phototron is a cylindrical evacuated glass tube with a photocathode, two grids, and a reflector electrode in a planar configuration. The phototron can be operated either in a biased mode where a low voltage is used to accelerate the electron beam produced by the photocathode or in an unbiased mode referred to as self-oscillation. The device is easily modulated by light input or voltage to broadcast in AM or FM. The range of operation of the present test model phototrons is from 2 to 200 MHz. G.R.

A82-11731#

BATTERY LIFE MODEL FOR SYNCHRONOUS ORBIT

J. KENNEDY, J. H. ENGLEMAN, R. S. BOGNER, and D. F. PICKETT (Hughes Aircraft Co., Culver City, CA) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 205-208.

An analysis of battery performance data collected from several spacecraft in synchronous orbit was made to determine if battery life could be predicted. The analysis covered only batteries that had been trickle-charged during solstice, since previous studies on open circuit charged batteries showed a more rapid voltage degradation. The batteries covered in this analysis have been in use for up to 6 years. A mathematical model of battery life was derived by use of statistical regression analysis. The measure of battery performance used was average battery cell end-of-discharge voltage. Battery performance was measured as a function of cell design parameters and battery operating parameters such as temperature, depth of discharge, and charge rates. The model predicts average cell voltage when all the applicable parameters and operating times are introduced into the model. Average cell voltage can be predicted to within about 0.01 volt, indicating a very accurate model. The model can also be used to show how battery life can be affected by varying the design and operating parameters. (Author)

A82-11732#

REAL-TIME LIFE TEST PERFORMANCE OF A NICKEL-HYDROGEN BATTERY

G. VAN OMMERING (Ford Aerospace and Communications Corp., Western Development Laboratories, Palo Alto, CA) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 209-211.

A real-time life test simulating geosynchronous orbit operation is conducted on a Ni-H₂ battery containing cells similar to those planned for flight on the Intelsat V spacecraft. Discharge data for two years indicate stable performance and confirm the absence of calendar life and temperature dependent Ni-H₂ cell degradation mechanisms. Data are compared with test results on an equivalent Ni-Cd battery, and it is found that a Ni-Cd system subjected to the same exposure would show signs of declining performance. Reconditioning behavior of the Ni-H₂ battery is also discussed. D.L.G.

A82-11738#

SERIES VS. SHUNT REGULATORS FOR POWER CONTROL IN SATELLITE POWER SYSTEMS

J. R. SHEIE, R. E. CORBETT, and M. C. GLASS (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 235-240.

The relative advantages and disadvantages of the series and shunt power-control approaches for various applications are examined, including high and low power and high and low earth orbit. A comparative study of the series and shunt power-control techniques is carried out, with consideration given to solar array sizing, power-control weight, equipment heat dissipation, power availability, and electromagnetic interference characteristics. A trade study example is given for specific applications where cost is the evaluation criterion. C.R.

A82-11739#

PROGRAMMABLE POWER PROCESSOR /P3/

F. E. LUKENS and R. L. MOSER (Martin Marietta Aerospace, Denver, CO) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 241-249.

The Programmable Power Processor (P3), an autonomous 18-kW power processor designed for use in large, high-power spacecraft power systems, is described. It is noted that operation

as a voltage regulator battery charger, shunt regulator or power limiter is achieved by selecting the resident ROM. It is shown that, with selection of the appropriate interface card, the P3 can operate with almost any spacecraft interface. C.R.

A82-11742#

SATELLITE POWER SYSTEMS /SPS/ ENERGY CONVERSION AND POWER MANAGEMENT

A. A. NUSSBERGER (Rockwell International Corp., Space Operations and Satellite Systems Div., Seal Beach, CA) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 261-265.

Impacts on the reference concept resulting from alternatives to microwave conversion, photovoltaic techniques, solar concentration ratio and power distribution voltage are discussed. Alternatives include solid state RF conversion such as sandwich configurations and end-mounted antenna configurations, and magnetron RF conversion including advanced pivoting panel configurations. Mass estimates are compared to a normalized point (2.3 kg/kw), and it is found that the estimates have grown over the past six years by a factor of 2.3 for the reference GaAs concept and 3.5 for the reference silicon concept. Mass savings from the use of multi bandgap solar cells is shown at an efficiency of 30%, and it is concluded that the advance magnetron concept incorporating improvements from evolving technology developments can provide a very competitive program. D.L.G.

A82-11743*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SOLAR POWER SATELLITE MICROWAVE POWER TRANSMISSION AND RECEPTION SYSTEM

W. FINNELL (NASA, Marshall Space Flight Center, Huntsville, AL) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 266-271. refs

The microwave power transmission and reception system of the Satellite Power System (SPS) has been intensively reviewed and assessed in a three-year concept development and evaluation program. This paper will review some concepts of SPS with particular emphasis on the design of the microwave power transmission and reception system. Technology requirements and proposals for meeting them will be discussed for various parts of the microwave system and to some degree for critical components such as power amplifiers. Specific subjects to be discussed are SPS concepts, antenna design, phase control, rectenna, and technology. (Author)

A82-11755*# National Aeronautics and Space Administration, Washington, D. C.

ADVANCES IN SPACE POWER RESEARCH AND TECHNOLOGY AT THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

J. P. MULLIN, L. P. RANDOLPH, W. R. HUDSON, and J. H. AMBRUS (NASA, Washington, DC) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 355-361.

Progress and plans in various areas of the NASA Space Power Program are discussed. Solar cell research is narrowed to GaAs, multibandgap, and thin Si cells for arrays in planar and concentrator configurations, with further work to increase cell efficiency, radiation hardness, develop flexible encapsulants, and reduce cost. Electrochemical research is concentrating on increasing energy and power density, cycle and wet stand life, reliability and cost reduction of batteries. Further development of the Ni-H₂ battery and O₂-H₂ fuel cell to multihundred kW with a 5 year life and 30,000 cycles is noted. Basic research is ongoing for alkali metal anodes for high energy density secondary cells. Nuclear thermoelectric propulsion is being developed for outer planets exploration propulsion systems, using Si-Ge generators, and studies

with rare earth chalcogenides and sulfides are mentioned. Power Systems Management seeks to harmonize increasing power supply levels with inner and outer spacecraft environments, circuits, demands, and automatic monitoring. Concomitant development of bipolar transistors, an infrared rectenna, spacecraft charging measurement, and larger heat pipe transport capacity are noted.

M.S.K.

A82-11760*# TRW Defense and Space Systems Group, Redondo Beach, Calif.

LOW COST, HIGH CONCENTRATION RATIO SOLAR CELL ARRAY FOR SPACE APPLICATIONS

R. E. PATTERSON, H. S. RAUSCHENBACH, M. D. CANNADY, U. S. WHANG (TRW Defense and Space Systems Group, Redondo Beach, CA), and W. L. CRABTREE (NASA, Marshall Space Flight Center, Huntsville, AL) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 383-389. refs

A miniaturized Cassegrainian-type concentrator solar array concept for space applications is described. In-orbit cell operating temperatures near 80 C are achieved with purely passive cell cooling and a net concentration ratio of 100. A multiplicity of miniaturized, rigid solar cell concentrator subassemblies are electrically interconnected in conventional fashion and mounted into rigid frames to form concentrator solar panel assemblies approximately 14-mm thick. A plurality of such interconnected panels forms a stowable and deployable solar cell blanket. It is projected that for 20% efficient silicon cells an array of 500 kW beginning-of-life output capability, including orbiter cradle structures, can be transported by a single shuttle orbiter flight into low earth orbit. In-orbit array specific performance is calculated to be approximately 100 W/sq m and 20 W/kg, including all stowage, deployment and array figure control equipment designed for a 30-year orbital life. Higher efficiency gallium arsenide and multiple band gap solar cells will improve these performance factors correspondingly. (Author)

A82-11763*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SOLAR CELL DEVELOPMENT FOR THE POWER EXTENSION PACKAGE

C. R. BARAONA (NASA, Lewis Research Center, Cleveland, OH) and J. L. CIONI (NASA, Johnson Space Center, Houston, TX) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 400-403. refs

The Power Extension Package (PEP), a 32-kilowatt, flexible-substrate, retrievable solar array system for use on the Space Shuttle, is described. It is noted that solar cell costs will be reduced by increasing cell area and simplifying cell and coverglass fabrication processes and specifications. The tests that have been carried out on the cells are described, among them a unique radiation damage test and a side-by-side comparison of candidate cell types with pre- and post-irradiation airplane calibration of outer space short-circuit current C.R.

A82-12504#

MECHANICAL AND NONLINEAR EFFECTS IN MICROWAVE POWER TRANSMISSION

G. FRANCESCHETTI and I. PINTO (Napoli, Universita, Naples, Italy) In: International Scientific Conference on Space, 21st, Rome, Italy, March 25, 26, 1981, Proceedings. Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1981, p. 39-41. refs

The radiation recoil force arising in the spacetenna-rectenna link of a microwave power transmission system is discussed. Consideration is also given to power-wasting nonlinear phenomena (harmonic generation) that could be excited by the microwave beam passing through the ionosphere. Nonlinear effects that may occur in the spacetenna and rectenna are also examined. B.J.

A82-14822* Boeing Aerospace Co., Seattle, Wash.

HIGH VOLTAGE CABLING FOR HIGH POWER SPACECRAFT

W. G. DUNBAR (Boeing Aerospace Co., Seattle, WA) In: NAECON 1981; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-21, 1981. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1981, p. 1216-1222.

(Contract NAS8-33432)

Studies by NASA have shown that many of the space missions proposed for the time period 1980 to 2000 will require large spacecraft structures to be assembled in orbit. Large antennas and power systems up to 2.5 MW size are predicted to supply the electrical/electronic subsystems, solar electric subsystems, solar electric propulsion, and space processing for the near-term programs. Platforms of 100 meters/length for stable foundations, utility stations, and supports for these multi-antenna and electronic powered mechanisms are also being considered. This paper includes the findings of an analytic and conceptual design study for large spacecraft power distribution, and electrical loads and their influence on the cable and connector requirements for these proposed large spacecraft. (Author)

A82-16004

THE INFLUENCE OF THE DESIGN CHARACTERISTICS OF EXPANDABLE TRUSS ANTENNAS ON THEIR RADIO-ENGINEERING PARAMETERS [VLIANIE KONSTRUKTIVNYKH OSOBENNOSTEI SKLADNYKH ANTENN FERMENNOGO TIPA NA IKH RADIOTEKHNICHESKIE PARAMETRY]

IU. A. KISANOV and N. M. FEIZULLA Antenny, no. 29, 1981, p. 26-32. In Russian. refs

An analysis is presented of the influence of such design features of expandable truss antennas as the hexagonal aperture and the approximation of the reflector surface by flat triangular elements on the surface utilization coefficient and the radiation pattern. It is shown that all technical solutions suitable for circular-aperture parabolic antennas are applicable to reflectors with a hexagonal aperture. Engineering formulas are derived that characterize the influence of the approximation of the antenna surface by flat triangular elements on the surface utilization coefficient and the radiation pattern. B.J.

A82-17982* Raytheon Co., Waltham, Mass.

STATUS OF THE MICROWAVE POWER TRANSMISSION COMPONENTS FOR THE SOLAR POWER SATELLITE

W. C. BROWN (Raytheon Co., Microwave and Power Tube Div., Waltham, MA) (Institute of Electrical and Electronics Engineers and International Union of Radio Science, International Microwave Symposium, Los Angeles, CA, June 15-19, 1981.) IEEE Transactions on Microwave Theory and Techniques, vol. MTT-29, Dec. 1981, p. 1319-1327. Research supported by the U.S. Department of Energy and NASA. refs

During the 1970-1980 time period a substantial advance has been made in developing all portions of a microwave power transmission system for the solar power satellite (SPS). The most recent advances pertain to the transmitting portion of the system in the satellite and are based upon experimental observations of the use of the magnetron combined with a passive directional device to convert it into a highly efficient directional amplifier with excellent low-noise properties and potentially very long life. The ability of its microwave output to track a phase reference makes it possible to combine it with many other radiating units to provide a highly coherent microwave beam. The ability of its output to track an amplitude reference while operating from a dc power source with varying voltage makes it possible to eliminate most of the power conditioning equipment that would otherwise be necessary. (Author)

A82-18317*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

VOLTAGE GRADIENTS IN SOLAR ARRAY CAVITIES AS POSSIBLE BREAKDOWN SITES IN SPACECRAFT-CHARGING-INDUCED DISCHARGES

N. J. STEVENS, H. E. MILLS, and L. ORANGE (NASA, Lewis Research Center, Cleveland, OH) (IEEE, U.S. Defense Nuclear Agency, NASA, and DOE, Annual Conference on Nuclear and Space Radiation, Effects, 18th, Seattle, WA, July 21-24, 1981.) IEEE Transactions on Nuclear Science, vol. NS-28, Dec. 1981, p. 4558-4562. refs

A possible explanation for environmentally-induced discharges on geosynchronous satellites exists in the electric fields formed in the cavities between solar cells - the small gaps formed by the cover slides, solar cells, metallic interconnects and insulating substrate. When exposed to a substorm environment, the cover slides become less negatively charged than the spacecraft ground. Hence, it is possible for metallic surfaces (usually silver mesh) to be at a negative potential in a cavity that has a 'positive' surface above it. If the resultant electric field becomes large enough, then the interconnect could emit electrons (probably by field emission) which could be accelerated to space by the positive voltage on the covers. An experimental study was conducted using a small solar array segment in which the interconnect potential was controlled by a power supply while the cover slides were irradiated by monoenergetic electrons. It was found that discharges could be triggered when the interconnect potential became at least 500 volts negative with respect to the cover slides. Analytical modeling of satellites exposed to substorm environments indicates that such gradients are possible. Therefore, it appears that this trigger mechanism for discharges is possible. Details of the experiment and modeling study are presented. (Author)

A82-19825

SOLAR-ENERGY PERSPECTIVES [PERSPEKTIVY SOLNECHNOI ENERGETIKI]

IU. S. BORTNIKOV, N. S. LIDORENKO, G. F. MUCHNIK, S. V. RIABIKOV, and D. S. STREBKOV Akademiia Nauk SSSR, Izvestiia, Energetika i Transport, Nov.-Dec. 1981, p. 3-12. In Russian.

The current status and perspectives of solar energy utilization are briefly reviewed. Optimal techniques for the design and application of solar energy converters are described, and the possible contribution of solar energy to the future energy economy is assessed. Particular consideration is given to the role of satellite solar power stations. B.J.

A82-20640* Boeing Aerospace Co., Kent, Wash.

MICROWAVE POWER - AN ENERGY TRANSMISSION ALTERNATIVE FOR THE YEAR 2000

E. NALOS and R. SPERBER (Boeing Aerospace Co., Kent, WA) In: NTC '80; National Telecommunications Conference, Houston, TX, November 30-December 4, 1980, Conference Record. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 48.1.1-48.1.5. Research supported by the U.S. Department of Energy refs (Contract NAS9-15636)

Recent technological advances related to the feasibility of efficient RF-dc rectification make it likely that by the year 2000 the transmission of power through space will have become a practical reality. Proposals have been made to power helicopters, aircraft, balloons, and rockets remotely. Other proposals consider the transfer of power from point to point on earth via relay through space or a transmission of power from large power sources in space. Attention has also been given to possibilities regarding the transmission of power between various points in the solar system. An outline is provided of the microwave power transmission system envisaged for the solar power satellite, taking into account the transmitting antenna, the receiver on earth, aspects of beam formation and control, transmitter options, the receiving antenna design, and cost and efficiency considerations. G.R.

A82-20641* LinCom Corp., Pasadena, Calif.

PERFORMANCE ANALYSIS AND SIMULATION OF THE SPS REFERENCE PHASE CONTROL SYSTEM

C. M. CHIE and A. V. KANTAK (LinCom Corp., Pasadena, CA) In: NTC '80; National Telecommunications Conference, Houston, TX, November 30-December 4, 1980, Conference Record. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 48.2.1-48.2.5. refs (Contract NAS9-15782)

The solar power satellite (SPS) concept envisions several hundred thousand synchronized microwave power amplifiers operating in parallel to produce an aggregate power output of 5-10 GW. This power is to be transferred to earth with the aid of a microwave/millimeter-wave beaming system operating in a synchronous orbit. The reference phase control system is considered along with aspects of pilot signal parameter selection. A power transponder analysis is conducted and an SPS performance evaluation is performed. Attention is given to system jitters and imperfections, the definition of power transfer efficiency, and the effects of system imperfections on SPS efficiency. It is found that the power transfer efficiency is relatively insensitive to the amplitude jitters. However, the effects of location jitters can produce a severe degradation of efficiency. G.R.

A82-20643*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SOLAR POWER SATELLITE MICROWAVE SYSTEM CONCEPTS AND PERFORMANCE CONSIDERATIONS

J. W. SEYL and G. D. ARNDT (NASA, Johnson Space Center, Houston, TX) In: NTC '80; National Telecommunications Conference, Houston, TX, November 30-December 4, 1980, Conference Record. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 48.4.1-48.4.5.

The phase control system is the fundamental element in the forming, steering and control of the solar power satellite (SPS) microwave power beam. This system must in essence automatically adjust the phase at each of the transmitter's 101,552 power amplifiers to compensate for differences in transmission path lengths to the earth-based receiving antenna (rectenna). SPS phase control system requirements are discussed, taking into account system concepts, a reference system description, reference system performance, ground based phase control concepts, and ionosphere considerations. It is pointed out that the importance of determining the ionospheric effects cannot be overemphasized. The permissible power density limit through the ionosphere is a critical SPS sizing factor and the phase control system must be able to accommodate errors induced by a heated ionosphere. G.R.

A82-20708*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SOLID-STATE ALTERNATIVES FOR THE SOLAR POWER SATELLITE

L. LEOPOLD and G. D. ARNDT (NASA, Johnson Space Center, Houston, TX) In: NTC '80; National Telecommunications Conference, Houston, TX, November 30-December 4, 1980, Conference Record. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 72.1.1-72.1.5.

A solid-state transmitter at S-band frequencies will allow many low-power antenna array elements fed directly by the solid-state amplifier modules to combine power for transmission to earth in space. Two configurations, one the separate antenna and the other a sandwich concept are discussed. The results of two small hardware development studies are presented. (Author)

A82-20713**MULTIBEAM ANTENNAS - A KEY ELEMENT IN HIGH CAPACITY GEOSTATIONARY PLATFORMS**

R. M. SORBELLO (COMSAT Laboratories, Clarksburg, MD) In: NTC '80; National Telecommunications Conference, Houston, TX, November 30-December 4, 1980, Conference Record. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 75.3.1-75.3.5. Research sponsored by the Communications Satellite Corp.

The chief benefit of geostationary platforms appears to be a substantial increase in communications capacity provided through multiple frequency reuse. The key element contributing to this high capacity will be multibeam antennas capable of generating a large number of spatially isolated beams. This paper examines the types of antennas and antenna performance required for several of the communications coverage concepts envisioned for the geostationary platform. Emphasis is placed on those areas of antenna technology which must be further developed to ensure successful implementation. B.J.

A82-25125**GREATER MESSAGE CAPACITY FOR SATELLITES**

B. I. EDELSON (Comsat General Corp., Washington, DC), R. B. MARSTEN (National Research Council, Washington, DC), and W. L. MORGAN (Clarksburg, Communications Center, Clarksburg, MD) IEEE Spectrum, vol. 19, Mar. 1982, p. 56-64.

The future requirements and means to achieve increased bandwidth utilization by communications satellites are examined. Noting that service and demand is doubling every four years for the Intelsat system, a reallocation of earth-based and satellite-based transmitters is mentioned as becoming necessary to avoid communications interference in selected bands and still allow dispersed reception for home microwave reception. The employment of polarized antennas is examined, along with antenna-beam shaping to achieve maximum use of available frequencies. Time division multiple accessing permits utilization of individual frequencies by several ground stations, and digital encoding of signal allows lower processing power while also requiring bandwidth compression. NASA is mentioned as preparing multimission satellites, ground-based links, and satellite-to-satellite links to relieve the congestion on presently used channels. M.S.K.

A82-25662**PILOT SIGNALS FOR LARGE ACTIVE RETRODIRECTIVE ARRAYS**

C. H. CHAN (Alabama, University, Huntsville, AL) Space Solar Power Review, vol. 2, no. 4, 1981, p. 347-353. refs

New designs for two-tone and multitone uplink signals for directing a downcoming SPS power beam are analyzed. Difficulties with symmetrically situated two-tone signals, which are broadcast around a downlink frequency, are examined in terms of problems due to the pi-ambiguity. Averaging the two frequencies is shown to potentially cause conjugation of the wrong phase, and a method of using two frequencies on the same side of the downlink frequency to avoid the pi-error is described, involving errors of less than 8 deg. Three- and four-tone uplinks are noted to offer opportunities to suppress biases due to the medium of transmission and compensate for distances some parts of the receiver array will be from the center. M.S.K.

A82-25663**SPS SIMULATED EFFECTS OF IONOSPHERIC HEATING ON THE PERFORMANCE OF TELECOMMUNICATION SYSTEMS - A REVIEW OF EXPERIMENTAL RESULTS**

C. M. RUSH (National Telecommunications and Information Administration, Institute for Telecommunication Sciences, Boulder, CO) Space Solar Power Review, vol. 2, no. 4, 1981, p. 355-366. Research supported by the U.S. Department of Energy. refs

The results of experimentally simulated SPS effects on the ionosphere in terms of effects on telecommunications are reported. The reference power beam is 23 mW/sq cm, enough to alter the temperature and electron density in the ionosphere through ohmic

interactions in the lower region and thermal self-focusing in the upper region. Overdense (reflective), and underdense (transparent) ionospheric heating mechanisms were examined with VLF signals from Omega, LF signals from Loran-C stations, and MF signals from AM broadcast stations, but solar flares at the time completely overrode any possible radio signal effects from a man-made source. Air-to-satellite measurements with the LES-8 spacecraft and the Fleetsatcom spacecraft to an aircraft showed changes in the signal received on the ground, due to underdense self-focusing. Further studies are indicated with higher powers and more beams.

M.S.K.

A82-25664* Old Dominion Univ., Norfolk, Va.**SOLAR-PUMPED ELECTRONIC-TO-VIBRATIONAL ENERGY TRANSFER LASERS**

W. L. HARRIES (Old Dominion University, Norfolk, VA) and J. W. WILSON (NASA, Langley Research Center, Hampton, VA) Space Solar Power Review, vol. 2, no. 4, 1981, p. 367-381. refs (Contract NSG-1568)

The possibility of using solar-pumped lasers as solar energy converters is examined. The absorbing media considered are halogens or halogen compounds, which are dissociated to yield excited atoms, which then hand over energy to a molecular lasing medium. Estimates of the temperature effects for a Br₂-CO₂-He system with He as the cooling gas are given. High temperatures can cause the lower energy levels of the CO₂ laser transition to be filled. The inverted populations are calculated and lasing should be possible. However, the efficiency is less than 0.001. Examination of other halogen-molecular lasing combinations (where the rate coefficients are known) indicate efficiencies in all cases of less than 0.005. (Author)

N82-11107*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.**VOLTAGE GRADIENTS IN SOLAR ARRAY CAVITIES AS POSSIBLE BREAKDOWN SITES IN SPACECRAFT-CHARGING-INDUCED DISCHARGES**

N. J. STEVENS, H. E. MILLS, and L. ORANGE 1981 10 p refs Presented at the Ann. Conf. on Nucl. and Space Radiation Effects, Seattle, 21-24 Jul. 1981 (NASA-TM-82710; E-1003) Avail: NTIS HC A02/MF A01 CSCL 10B

A possible explanation for environmentally-induced discharges on geosynchronous satellites exists in the electric fields formed in the cavities between solar cells - the small gaps formed by the cover slides, solar cells, metallic interconnects and insulating substrate. When exposed to a substorm environment, the cover slides become less negatively charged than the spacecraft ground. If the resultant electric field becomes large enough, then the interconnect could emit electrons (probably by field emission) which could be accelerated to space by the positive voltage on the covers. An experimental study was conducted using a small solar array segment in which the interconnect potential was controlled by a power supply while the cover slides were irradiated by monoenergetic electrons. It was found that discharges could be triggered when the interconnect potential became at least 500 volts negative with respect to the cover slides. Analytical modeling of satellites exposed to substorm environments indicates that such gradients are possible. Therefore, it appears that this trigger mechanism for discharges is possible. T.M.

N82-11109*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.**CONCEPT FOR A POWER SYSTEM CONTROLLER FOR LARGE SPACE ELECTRICAL POWER SYSTEMS**

L. F. LOLLAR, J. R. LANIER, JR., and J. R. GRAVES Nov. 1981 15 p refs (NASA-TP-1939) Avail: NTIS HC A02/MF A01 CSCL 22B

The development of technology for a fail-operational power system controller (PSC) utilizing microprocessor technology for managing the distribution and power processor subsystems of a large multi-kW space electrical power system is discussed. The specific functions which must be performed by the PSC, the best

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microprocessor available to do the job, and the feasibility, cost savings, and applications of a PSC were determined. A limited function breadboard version of a PSC was developed to demonstrate the concept and potential cost savings. A.R.H.

N82-11544*# Teledyne Brown Engineering, Huntsville, Ala. Engineering Services Div.

INVESTIGATION OF DIRECT SOLAR-TO-MICROWAVE ENERGY CONVERSION TECHNIQUES Final Report

N. E. CHATTERTON, T. K. MOOKHERJI, and P. K. WUNSCH
Jan. 1978 107 p refs

(Contract NAS8-32643)

(NASA-CR-161883; ESD-78-MSFC-2174) Avail: NTIS HC A06/MF A01 CSCL 10A

Identification of alternative methods of producing microwave energy from solar radiation for purposes of directing power to the Earth from space is investigated. Specifically, methods of conversion of optical radiation into microwave radiation by the most direct means are investigated. Approaches based on demonstrated device functioning and basic phenomenologies are developed. There is no system concept developed, that is competitive with current baseline concepts. The most direct methods of conversion appear to require an initial step of production of coherent laser radiation. Other methods generally require production of electron streams for use in solid-state or cavity-oscillator systems. Further development is suggested to be worthwhile for suggested devices and on concepts utilizing a free-electron stream for the intraspace station power transport mechanism. S.L.

N82-12540*# Boeing Aerospace Co., Seattle, Wash.

SPS LARGE ARRAY SIMULATION

S. RATHJEN, B. R. SPERBER, and E. J. NALOS /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 14-23 1980

Avail: NTIS HC A99/MF A01 CSCL 10A

The computer programming efforts were directed primarily to beam pattern analysis. The computer programs used for simulation provide: verification of the reference design; definition of feasible departures such as quantized distributions; the study of far-out sidelobe roll-off characteristics; the analysis of errors and failures; illumination function analysis to develop beam patterns for efficient collection; and beam shaping synthesis to meet environmental constraints. T.M.

N82-12541*# Axiomatix, Los Angeles, Calif.

AN ACTIVE ALIGNMENT SCHEME FOR THE MPTS ARRAY

R. IWASAKI /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 26-31 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

In order to maximize the efficiency of the microwave power transmission system (MPTS), the surface of the array antenna must be extremely flat, which is difficult to achieve using passive techniques over the 1 km dimensions of the array. In order to achieve and maintain this required flatness, a rotating laser beam used for leveling applications on Earth was utilized as a reference system. A photoconductive sensor with a reflective collecting surface was used to determine the displacement and polarity of any misalignment and automatically engage a stepping motor to drive a variable-length mechanism to make the necessary corrections. Once aligned, little power is dissipated since a nulling bridge circuit that centers on the beam is used, an important alignment feature since even laser beams broaden considerably at 1 km distances. T.M.

N82-12542*# Los Alamos Scientific Lab., N. Mex.

IONOSPHERIC POWER BEAM STUDIES

L. M. DUNCAN and W. E. GORDON (Rice Univ.) /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 32-43 1980

Avail: NTIS HC A99/MF A01 CSCL 10A

A power density level of 23 mW/sq cm is presented as a design specification based on theoretical calculations of a threshold

for microwave ionosphere nonlinear interaction (thermal runaway). For comparable power densities, enhanced electron heating is observed to change the electron temperature by a factor of two or three, but not by an order of magnitude. T.M.

N82-12543*# Emmanuel Coll., Boston, Mass.

PROPOSED EXPERIMENTAL STUDIES FOR ASSESSING IONOSPHERIC PERTURBATIONS ON SPS UPLINK PILOT BEAM SIGNAL

S. BASU and S. BASU /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 44-54 1980 refs

(Contract F19628-78-C-0005; NSF ATM-78-25264)

Avail: NTIS HC A99/MF A01 CSCL 10A

The microwave beam of the proposed Solar Power Satellite (SPS) at geosynchronous altitude is to be formed and directed by phase information derived from a pilot signal at 2.45 GHz transmitted from ground and received in a number of module locations on the SPS antenna. The frequency of the pilot signal was chosen to be sufficiently low as to avoid the effects of strong scattering by turbulence in the neutral atmosphere and yet high enough to avoid any possible refractive effects caused by the ionized upper atmosphere. The propagation of the uplink pilot signal through the ionosphere which contains natural and possibly some artificial irregularities, was studied. T.M.

N82-12544*# LinCom Corp., Pasadena, Calif.

PERFORMANCE ANALYSIS AND SIMULATION OF THE SPS REFERENCE PHASE CONTROL SYSTEM

W. C. LINDSEY and C. M. CHIE /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 58-74 1980 refs

(Contract NAS9-15782)

Avail: NTIS HC A99/MF A01 CSCL 10A

Key results pertinent to the SPS reference phase control system design are summarized. These results are a consequence of extensive system engineering tradeoffs provided via mathematical modeling, optimization, analysis and the development/utilization of a computer simulation tool called SOLARSIM. T.M.

N82-12545*# Lockheed Engineering and Management Services Co., Inc., Houston, Tex.

DESIGN AND BREADBOARD EVALUATION OF THE SPS REFERENCE PHASE CONTROL SYSTEM CONCEPT

P. M. HOPKINS and V. R. RAO /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 75-84 1980

(Contract NAS9-15800)

Avail: NTIS HC A99/MF A01 CSCL 10A

Efficient operation of a very large phased array such as the proposed solar power satellite, requires precision focusing and pointing of the power beam; i.e., the power beam must have a planar wavefront directed precisely at the center of the target antenna (rectenna). To maintain such a power beam requires real-time phase compensation at each subaperture in order to adjust for structural deformations and other transitory factors. In the current solar power satellite (SPS) baseline, the spaceborne antenna (Spacetenna) is an active retrodirective array. A pilot signal transmitted from the center of the rectenna is phase-conjugated at each subaperture (power module) of the spacetenna, thereby assuring that the radiated composite wave is focused on the target. This scheme requires a large amount of precision electronic circuitry on the spacetenna. Specifically, pilot receivers must be located at each power module and an adaptive distribution network is required in order to provide a properly phased reference signal at each conjugator. T.M.

N82-12546*# LinCom Corp., Pasadena, Calif.
COHERENT MULTIPLE TONE TECHNIQUE FOR GROUND BASED SPS PHASE CONTROL

C. M. CHIE *In* NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 85-94 1980 refs

(Contract NAS9-15782)

Avail: NTIS HC A99/MF A01 CSCL 10A

The ground based phase control concept was studied as an alternative approach to the reference SPS phase control system. The details of the ground based phase control system study are documented. The coherent multiple tone technique used for the ground based phase measurement waveform design and phase control system is summarized. T.M.

N82-12547*# Novar Electronics Corp., Barberton, Ohio.

AN INTERFEROMETER-BASED PHASE CONTROL SYSTEM

J. H. OTT and J. S. RICE *In* NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 95-98 1980 refs

Avail: NTIS HC A99/MF A01 CSCL 10A

A system for focusing and pointing the SPS power beam is discussed. The system is ground based and closed loop. One receiving antenna is required on Earth. A conventional uplink data channel transmits an 8-bit phase error correlation back to the SPS for sequential calibration of each power module. Beam pointing resolution is better than 140 meters at the Rectenna. T.M.

N82-12549*# Boeing Aerospace Co., Seattle, Wash.

SPS PHASE CONTROL STUDIES

W. W. LUND, B. R. SPERBER, and G. R. WOODCOCK *In* NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 100-109 1980

Avail: NTIS HC A99/MF A01 CSCL 10A

To properly point and form the SPS microwave power beam, the outputs of the power amplifiers in the transmitting array must be phased in a specific and coherent fashion. The purpose of the SPB phase control system is to bring this about reliably. A number of different phase control schemes were studied. The one selected for the SPS baseline system is a retrodirective CW phase that is distributed via fiber optics. The basis of this selection is relative technical simplicity and requisite assurance of success. T.M.

N82-12550*# Boeing Aerospace Co., Seattle, Wash.

SPS FIBER OPTIC LINK ASSESSMENT

T. O. LINDSAY and E. J. NALOS *In* NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 110-114 1980

Avail: NTIS HC A99/MF A01 CSCL 10A

Fiber optic technology was selected in the SPS baseline design to transmit a stable phase reference throughout the microwave array. Over a hundred thousand microwave modules are electronically steered by the phase reference signal to form the power beam at the ground receiving station. The initially selected IF distribution frequency of the phase reference signal was set at 980 MHz or a submultiple of it. Fiber optics offers some significant advantages in view of the SPS application. Optical transmission is highly immune to EMI/RFI, which is expected to be severe when considering the low distribution power. In addition, there will be savings in both mass, physical size, and potentially in cost. T.M.

N82-12551*# Rockwell International Corp., Pittsburgh, Pa.

IONOSPHERIC EFFECTS IN ACTIVE RETRODIRECTIVE ARRAY AND MITIGATING SYSTEM DESIGN

A. K. NANDI and C. Y. TOMITA *In* NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 115-125 1980 refs

Avail: NTIS HC A99/MF A01 CSCL 10A

The operation of an active retrodirective array (ARA) in an ionospheric environment (that is either stationary or slowly-varying) was examined. The restrictions imposed on the pilot-signal structure as a result of such operation are analyzed. A 3-tone pilot beam system is defined which first estimates the total electron content

along paths of interest and then utilizes this information to aid the phase conjugator so that correct beam pointing can be achieved.

T.M.

N82-12552*# Boeing Aerospace Co., Seattle, Wash.

HIGH EFFICIENCY SPS KLYSTRON DESIGN

E. J. NALOS *In* NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 127-136 1980

Avail: NTIS HC A99/MF A01 CSCL 10A

The most likely compact configuration to realize both high efficiency and high gain is a 5-6 cavity design focused by an electromagnet. An outline of a potential klystron configuration is given. The selected power output of 70 kW CW resulted from a maximum assumed operating voltage of 40 kV. The basic klystron efficiency cannot be expected to exceed 70-75% without collector depression. Although impressive gains were achieved in raising the basic efficiency from 50% to 70% or so with a multi-stage collector, the estimated efficiency improvement due to 5-stage collector at the 75% level is only about 8% resulting in an overall efficiency of about 83%. T.M.

N82-12553*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYTIC INVESTIGATION OF EFFICIENCY AND PERFORMANCE LIMITS IN KLYSTRON AMPLIFIERS USING MULTIDIMENSIONAL COMPUTER PROGRAMS; MULTI-STAGE DEPRESSED COLLECTORS; AND THERMIONIC CATHODE LIFE STUDIES

H. G. KOSMAHL *In* NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 139-146 1980 refs

Avail: NTIS HC A99/MF A01 CSCL 10A

Due to complexity of the program which used a hydrodynamic, axially and radially deformable disk-ring model and the resulting long computing time only the output gap was investigated. Results from independent studies were used to initiate the starting conditions for the electrons and the RF voltage using our program. Although this method of computation is less exact than processing the entire klystron interaction in 3-Dimensions it is shown that, for a confined flow focused throughout the penultimate cavity, radial velocities remain very small and the beam is highly laminar. It is concluded that possible errors resulting from treating only the output cavity in 3-D would remain small. T.M.

N82-12554*# Raytheon Co., Waltham, Mass. New Products Center.

THE ADAPTING OF THE CROSSED-FIELD DIRECTIONAL AMPLIFIER TO THE REQUIREMENTS OF THE SPS Progress Report

W. C. BROWN *In* NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 147-155 1980 refs

Avail: NTIS HC A99/MF A01 CSCL 10A

Progress in adapting the crossed-field directional amplifier to the SPS is reviewed. Special emphasis is given to (1) recent developments in controlling the phase and amplitude of the microwave power output, (2) a received architecture for its placement in the subarray, and (3) recent developments in the critical pivotal areas of noise, potential cathode life, and efficiency. Author

N82-12555*# Boeing Aerospace Co., Seattle, Wash.

SPS ANTENNA ELEMENT EVALUATION

C. D. LUNDEN, W. W. LUND, and E. J. NALOS *In* NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception 158-165 1980

Avail: NTIS HC A99/MF A01 CSCL 10A

The SPS transmitting array requires an architecture which will provide a low weight, high efficiency and high structural rigidity. Waveguide slot arrays constitute the most desirable option. Consequently, such an array was chosen for the SPS. Waveguide slot arrays offer high efficiency, uniform illumination, and are fairly

lightweight. Bandwidths of such arrays are narrow, typically 1/2-2%. Although this does not directly impact the SPS, which transmits power at a single frequency of 2.45 GHz, the narrow bandwidth does constrain the thermal and mechanical tolerances of the antenna. The purpose of this program is to better define the electronic aspects of an SPS specific waveguide slot array. The specific aims of the program are as follows: (1) To build a full-scale half-module, 10 stick, array, the design parameters for which are to be determined analytical considerations tempered by experimental data on a single slotted radiating stick, (2) To experimentally evaluate the completed array with respect to antenna pattern, impedance and return loss; and (3) To measure swept transmission amplitude and phase to provide a data base for design of a receiving antenna. L.F.M.

N82-12556*# Rockwell International Corp., Pittsburgh, Pa.
THE RESONANT CAVITY RADIATOR (RCR)
 K. G. SCHROEDER, R. L. CARLISE, and C. Y. TOMITA /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 167-177 1980
 Avail: NTIS HC A99/MF A01 CSCL 10A

The fundamental theory of MW antenna operation and basic array technology development status was used in the design of the 1-km diameter 5-Gw SPS microwave antenna. However, the aperture size and the high efficiency requirements make the MW antenna extremely complex. Studies show that the slotted waveguide array is one of the most efficient radiators for the antenna. Subsequent analyses show that the temperature interface between waveguides and dc-RF conversion tubes can cause severe thermal design problems on the array. An alternate design, the Resonant Cavity Radiator, is described here. L.F.M.

N82-12557*# Boeing Aerospace Co., Seattle, Wash.
EVALUATION OF THICK WALL WAVE GUIDE ELEMENT
 E. J. NALOS /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 180-187 1980
 Avail: NTIS HC A99/MF A01 CSCL 10A

The SPS transmitting array requires an architecture which will provide a low weight, high efficiency and high structural rigidity. As noted above, waveguide slot arrays constitute the most desirable option. Consequently, such an array has been chosen for the SPS. Waveguide slot arrays offer high efficiency, uniform illumination, are fairly lightweight. Bandwidths of such arrays are narrow, typically 1/2-2%. Although this does not directly impact the SPS, which transmits power at a single frequency of 2.45 GHz, the narrow bandwidth does constrain the thermal and mechanical tolerances of the antenna. The purpose of this program is to better define the electronic aspects of an SPS specific waveguide slot array. The specific aims of the program are as follows: (1) To build a full-scale half-module, 10 stick, array, the design parameters for which are to be determined by analytical considerations tempered by experimental data on a single slotted radiating stick, (2) To experimentally evaluate the completed array with respect to antenna pattern, impedance and return loss, and (3) To measure swept transmission amplitude and phase to provide a data base for design of a receiving antenna. L.F.M.

N82-12558*# Raytheon Co., Waltham, Mass. New Products Center.
METHOD FOR PRECISION FORMING OF LOW-COST, THIN-WALLED SLOTTED WAVEGUIDE ARRAYS FOR THE SPS
 W. C. BROWN /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 188-190 1980
 Avail: NTIS HC A99/MF A01 CSCL 10A

A method for the precision-forming of thin-walled, slotted waveguide arrays was devised. Models were constructed with temporary tools and evaluated. The application of the method to the SPS requirements is discussed. Author

N82-12559*# Georgia Inst. of Tech., Atlanta. Engineering Experiment Station.

CONSIDERATIONS FOR HIGH ACCURACY RADIATION EFFICIENCY MEASUREMENTS FOR THE SOLAR POWER SATELLITE (SPS) SUBARRAYS

D. J. KOZAKOFF, J. M. SCHUCHARDT, and C. E. RYAN /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 191-200 1980 refs
 (Contract NAS8-33605)

Avail: NTIS HC A99/MF A01 CSCL 10A

The relatively large apertures to be used in SPS, small half-power beamwidths, and the desire to accurately quantify antenna performance dictate the requirement for specialized measurements techniques. Objectives include the following: (1) For 10-meter square subarray panels, quantify considerations for measuring power in the transmit beam and radiation efficiency to + or - 1 percent (+ or - 0.04 dB) accuracy. (2) Evaluate measurement performance potential of far-field elevated and ground reflection ranges and near-field techniques. (3) Identify the state-of-the-art of critical components and/or unique facilities required. (4) Perform relative cost, complexity and performance tradeoffs for techniques capable of achieving accuracy objectives. The precision required by the techniques discussed below are not obtained by current methods which are capable of + or - 10 percent (+ or - dB) performance. In virtually every area associated with these planned measurements, advances in state-of-the-art are required. L.F.M.

N82-12560*# Raytheon Co., Waltham, Mass. New Products Center.

THE HISTORY OF THE DEVELOPMENT OF THE RECTENNA

W. C. BROWN /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 203-212 1980 refs

Avail: NTIS HC A99/MF A01 CSCL 10A

The history of the development of the rectenna is first reviewed through its early conceptual and developmental phases in which the Air Force and Raytheon Company were primarily involved. The intermediate period of development which involved NASA, Jet Propulsion Laboratory, and Raytheon is then reviewed. Some selective aspects of the current SPS rectenna development are examined. Author

N82-12561*# Boeing Aerospace Co., Seattle, Wash.

RECTENNA SYSTEM DESIGN

G. R. WOODCOCK and R. W. ANDRYCZYK (GE) /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 213-222 1980

Avail: NTIS HC A99/MF A01 CSCL 10A

Various rectenna system options are discussed. Among these are the half-wave dipole, modified half-wave dipole, yagi, half-wave dipole stripline, air dielectric transmission line feed, full wavelength dipole stripline, parabolic horn, and parabolic trough. L.F.M.

N82-12562*# Rensselaer Polytechnic Inst., Troy, N. Y.

RECTENNA SESSION: MICRO ASPECTS

R. J. GUTMANN /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 223-231 1980 refs

Avail: NTIS HC A99/MF A01 CSCL 10A

Two micro aspects of rectenna design are discussed: evaluation of the degradation in net rectenna RF to DC conversion efficiency due to power density variations across the rectenna (power combining analysis) and design of Yagi-Uda receiving elements to reduce rectenna cost by decreasing the number of conversion circuits (directional receiving elements). The first of these involves resolving a fundamental question of efficiency potential with a rectenna, while the second involves a design modification with a large potential cost saving. L.F.M.

N82-12563*# Novar Electronics Corp., Barberton, Ohio.
A THEORETICAL STUDY OF MICROWAVE BEAM ABSORPTION BY A RECTENNA

J. H. OTT, J. S. RICE, and D. C. THORN /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 234-240 1981 refs

Avail: NTIS HC A99/MF A01 CSCL 10A

The results of a theoretical study of microwave beam absorption by a Rectenna are given. Total absorption of the power beam is shown to be theoretically possible. Several improvements in the Rectenna design are indicated as a result of analytic modeling. The nature of Rectenna scattering and atmospheric effects are discussed. Author

N82-12564*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

RECTENNA ARRAY MEASUREMENT RESULTS

R. M. DICKINSON /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 244-250 1980 refs

Avail: NTIS HC A99/MF A01 CSCL 10A

The measured performance characteristics of a rectenna array are reviewed and compared to the performance of a single element. It is shown that the performance may be extrapolated from the individual element to that of the collection of elements. Techniques for current and voltage combining were demonstrated. The array performance as a function of various operating parameters is characterized and techniques for overvoltage protection and automatic fault clearing in the array demonstrated. A method for detecting failed elements also exists. Instrumentation for deriving performance effectiveness is described. Measured harmonic radiation patterns and fundamental frequency scattered patterns for a low level illumination rectenna array are presented. Author

N82-12565*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SESSION ON SOLID STATE: INTRODUCTION

/in its Workshop on Microwave Power Transmission and Reception p 253-257 1980

Avail: NTIS HC A99/MF A01 CSCL 10A

The possibilities of using solid state devices as part of the Satellite Solar Power System are discussed. Solid state advantages and disadvantages are presented along with two potential concepts for use of solid state in the system design. L.F.M.

N82-12566*# Boeing Aerospace Co., Seattle, Wash.
MODIFIED REFERENCE SPS WITH SOLID STATE TRANSMITTING ANTENNA

G. R. WOODCOCK and B. R. SPERBER /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 258-267 1980

Avail: NTIS HC A99/MF A01 CSCL 10A

The motivations for considering solid state microwave power amplifiers for the solar power satellite transmitting antenna are the possibilities of greatly increased system reliability due to elimination of electron tube cathodes, a lower mass per unit power and transmitting array area due to the high power densities obtainable in semiconductors, and, probably, cost savings due to development of small hardware items that can be handled by individuals instead of organizations. In order to provide a fair assessment where we stand today with regard to solid state SPS technology, the design described here is close to that of the NASA/DOE reference and is implemented using today's solid state technology with only a small 'push'. The small push is raising the efficiency of DC-RF conversion from the .68 obtained by RCA in 1975 to somewhat over .8 of the solid state SPS. This is generally considered feasible by semiconductor industry representatives. Other solid state SPS configurations can yield somewhat better performance. However, these generally do not provide as fair a vehicle for comparison with the reference and usually also incorporate somewhat more advanced technologies. L.F.M.

N82-12567*# Boeing Aerospace Co., Seattle, Wash.

SPS SOLID STATE ANTENNA POWER COMBINER

G. W. FITZSIMMONS /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 268-277 1980

Avail: NTIS HC A99/MF A01 CSCL 10A

Solid state dc-rf converters offer potential improvements in reliability, mass and low voltage operation, provided that anticipated efficiencies in excess of 80 percent can be realized. Field effect transistors offer the greatest potential in the SPS frequency band at 2.45 GHz. To implement this approach it is essential that means be found to sum the power of many relatively low power solid state sources in a low-loss manner, and that means be provided to properly control the phase of the outputs of the large number of solid state sources required. To avoid the power combining losses associated with circuit hybrids it was proposed that the power from multiple solid state amplifiers be combined by direct coupling of each amplifier's output to the radiating antenna structure. The selected power-combining antenna consists of a unique printed (metalized) microstrip circuit on a ceramic type dielectric substrate which is backed by a shallow lightweight aluminum cavity which sums the power of four microwave sources. The antenna behaves like two one-half wavelength slot-line antennas coupled together via their common cavity structure. L.F.M.

N82-12568*# Rockwell International Corp., Pittsburgh, Pa.
SOLID-STATE RETRODIRECTIVE PHASED ARRAY CONCEPTS FOR MICROWAVE POWER TRANSMISSION FROM SOLAR POWER SATELLITE

K. G. SCHROEDER and I. K. PETROFF /in NASA. Johnson Space Center Workshop on Microwave Power Transmission and Reception p 279-298 1980 refs

Avail: NTIS HC A99/MF A01 CSCL 10A

Two prototype solid-state phased array systems concepts for potential use in the Solar Power Satellite are described. In both concepts, the beam is centered on the rectenna by means of phase conjugation of a pilot signal emanating from the ground. Also discussed is on-going solid-state amplifier development. L.F.M.

N82-13514# Solarex Corp., Rockville, Md.
SILICON SOLAR CELL OPTIMIZATION Final Report, 15 Aug. 1978 - 15 Feb. 1981

A. L. SCHEININE, J. H. WOHLGEMUTH, and E. SPARKS Wright-Patterson AFB, Ohio AFWAL Jun. 1981 99 p refs (Contract F33615-78-C-2039; AF PROJ. 3145) (AD-A106005; AFWAL-TR-81-2052) Avail: NTIS HC A05/MF A01 CSCL 10B

This research program has resulted in improvements in vertical junction solar cell techniques leading to higher efficiencies and improved handleability. Vertical junction solar cells have now been fabricated with AMO conversion efficiency greater than 15% (25 C). A variety of cells have been fabricated including different groove depths, substrate thicknesses and bulk resistivities. Cell performance has been measured both before and after irradiation. Theoretical analyses has been performed to generate computer models of I-V curves for various cell geometries. Author (GRA)

N82-14636*# General Dynamics/Convair, San Diego, Calif.
STUDY OF MULTI-MEGAWATT TECHNOLOGY NEEDS FOR PHOTOVOLTAIC SPACE POWER SYSTEMS. VOLUME 1: EXECUTIVE SUMMARY

D. M. PETERSON and R. L. PLEASANT 1 Aug. 1981 28 p refs 2 Vol.

(Contract NAS3-21951)

(NASA-CR-165323-VOL-1; REPT-111-2401-204) Avail: NTIS HC A03/MF A01 CSCL 10A

Possible missions requiring multimegawatt photovoltaic space power systems in the 1990's time frame and associated power system technology needs are examined. The following concepts for photovoltaic power approaches are considered: planar arrays, concentrating arrays, hybrid systems using Rankine engines,

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thermophotovoltaic and AC/DC power management approaches, battery, fuel cell, flywheel energy storage, and interactions with the electrical ion engine injection and stationkeeping system. The levels of modularity for efficient, safe, constructable, serviceable, and cost effective system design are analyzed, and the benefits of alternate approaches developed. Both manned low Earth orbit and unmanned geosynchronous Earth orbit applications were examined for technological development. Technology developments applicable to power systems which appear to have benefits independent of the absolute power level are suggested.

M.D.K.

N82-16162*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ELECTROMAGNETIC DESIGN OF A MICROWAVE RADIOMETER ANTENNA SYSTEM

P. K. AGRAWAL (RCA, Moorestown, N.J.) and C. R. COCKRELL *In its* The Microwave Radiometer Spacecraft p 129-136 Dec. 1981 refs

Avail: NTIS HC A11/MF A01 CSCL 22B

A preliminary electromagnetic (EM) design of a radiometric antenna system was developed for the microwave radiometer spacecraft mission. The antenna system consists of a large spherical reflector and an array of feed horns along a concentric circular arc in front of the reflector. The reflector antenna was sized to simultaneously produce 200 contiguous 1 km diameter footprints with an overall beam efficiency of 90 percent, and the feed horns and feed horn array were designed to monitor the radiation from the footprints.

Author

N82-16163*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EFFECTS OF RANDOM DISTORTIONS ON THE SURFACE ACCURACY OF A LARGE ANTENNA

C. R. COCKRELL and L. STATON *In its* The Microwave Radiometer Spacecraft p 137-140 Dec. 1981 refs

Avail: NTIS HC A11/MF A01 CSCL 22B

The effects of random reflector distortions or irregularities on a reflector's radiation pattern are discussed. The importance of such surface deviations with respect to a radiometric reflector antenna is addressed.

Author

N82-16164*# Harris Corp., Melbourne, Fla.

EFFECTS OF ANTENNA BLOCKAGE ON RADIO FREQUENCY PERFORMANCE OF THE MICROWAVE RADIOMETER SPACECRAFT

L. D. SIKES and T. HOWER *In NASA. Langley Research Center The Microwave Radiometer Spacecraft p 141-165 Dec. 1981 refs*

Avail: NTIS HC A11/MF A01 CSCL 22B

Radio frequency scaled models of the microwave radiometer spacecraft suspended feed concept were tested to determine the effects of aperture blockage on the antenna radiation pattern. Contributors to the uncertainty of the test measurements were evaluated, and an estimate of the blockage effects was made for comparison with the test measurements. The gain loss budget associated with reflector performance characteristics (aperture blockage, surface reflectivity, reflector roughness, and defocus) was determined.

Author

N82-16166*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

BIAXIAL AND ELECTROSTATIC TENSIONING EFFECTS ON THIN MEMBRANE MATERIALS

W. F. HINSON, J. W. GOSLEE, J. R. MCILHANEY (Kentron International, Inc.), and J. H. RAMSEY (Kentron International, Inc.) *In its* The Microwave Radiometer Spacecraft p 189-204 Dec. 1981 refs

Avail: NTIS HC A11/MF A01 CSCL 22B

Thin membrane materials were subjected to biaxial and electrostatic tensioning loads to study techniques for maintaining surface smoothness of a thin membrane antenna. The basic mechanical and electrical setup for the tests is described and

preliminary measurements of surface smoothness and surface deviation are presented.

Author

N82-17607*# United Technologies Corp., South Windsor, Conn. Power Systems Div.

ELECTROCHEMICAL ENERGY STORAGE FOR AN ORBITING SPACE STATION

R. E. MARTIN Dec. 1981 61 p refs

(Contract NAS3-21293)

(NASA-CR-165436; FCR-3142) Avail: NTIS HC A04/MF A01 CSCL 10C

The system weight of a multi hundred kilowatt fuel cell electrolysis cell energy storage system based upon alkaline electrochemical cell technology for use in a future orbiting space station in low Earth orbit (LEO) was studied. Preliminary system conceptual design, fuel cell module performance characteristics, subsystem and system weights, and overall system efficiency are identified. The impact of fuel cell module operating temperature and efficiency upon energy storage system weight is investigated. The weight of an advanced technology system featuring high strength filament wound reactant tanks and a fuel cell module employing lightweight graphite electrolyte reservoir plates is defined.

E.A.K.

N82-18579*# Ball Aerospace Systems Div., Boulder, Colo.

PRELIMINARY STUDY ON THE USE OF LASERS FOR THE TRANSMISSION OF POWER

In NASA. Langley Research Center Space Laser Power Transmission System Studies p 15-32 Feb. 1982

Avail: NTIS HC A10/MF A01 CSCL 20E

The use of lasers in space is outlined. Possibilities and ideas are presented. The economic payoff of lasers in space in supplying energy for the Earth is considered. Possible operational advantages and economies for the user of space to space energy transmission are addressed. The development of large space power stations to beam energy to Earth is discussed. Applications on Earth and comparisons with microwave systems are emphasized.

N.W.

N82-18580*# Schafer (W. J.) Associates, Inc., Arlington, Va.

A STUDY TO SURVEY NASA LASER APPLICATIONS AND IDENTIFY SUITABLE LASERS FOR SPECIFIC NASA NEEDS

In NASA. Langley Research Center Space Laser Transmission System Studies p 33-44 Feb. 1982 refs

Avail: NTIS HC A10/MF A01 CSCL 20E

All potential applications of high power lasers which might, in particular, use the JPL copper-halide laser under development were considered for study. A wide range of applications were identified with strong emphasis on remote sensing applications. Power beaming and laser propulsion were also identified as major areas of interest to NASA.

N.W.

N82-18581*# Schafer (W. J.) Associates, Inc., Arlington, Va.

INVESTIGATION OF POSSIBILITIES FOR SOLAR-POWERED HIGH-ENERGY LASERS IN SPACE

In NASA. Langley Research Center Space Laser Power Transmission System Studies p 45-56 Feb. 1982

Avail: NTIS HC A10/MF A01 CSCL 20E

Solar pumped lasers were investigated. The literature was reviewed for possible solar laser candidates from optical pumping experiments. A baseline CO electric discharge laser system was shown to be technically feasible. The most promising direct solar pumped laser was identified to be CF3I. Using the 'STAG' solar laser concept and CF3I, it was found that such a system could be weight competitive with the baseline CO laser system.

N.W.

N82-18582*# Mathematical Sciences Northwest, Inc., Bellevue, Wash.

DESIGN INVESTIGATION OF SOLAR-POWERED LASERS FOR SPACE APPLICATIONS

In NASA. Langley Research Center Space Laser Power Transmission System Studies p 77-84 Feb. 1982

Avail: NTIS HC A10/MF A01 CSCL 20E

The feasibility of using solar powered continuous wave (CW) lasers for space power transmission was investigated. Competing conceptual designs are considered. Optical pumping is summarized. Solar pumped Lasant type lasers are outlined. Indirect solar pumped lasers are considered. N.W.

N82-18585*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

LASER POWER CONVERSION SYSTEM ANALYSIS

In NASA. Langley Research Center Space Laser Power Transmission System Studies p 145-158 Feb. 1982 refs

Avail: NTIS HC A10/MF A01 CSCL 20E

Orbit to orbit and orbit to ground laser power conversion systems and power transfer are discussed. A system overview is presented. Pilot program parameters are considered: SLPS assumptions are listed, a laser SPS overview is presented, specifications are listed, and SLPS coats are considered. N.W.

N82-18586*# Mathematical Sciences Northwest, Inc., Bellevue, Wash.

SPACE LASER POWER TRANSMISSION

In NASA. Langley Research Center Space Laser Power Transmission System Studies p 165-174 Feb. 1982 refs

Avail: NTIS HC A10/MF A01 CSCL 20E

Proposed laser transmission applications are reviewed. Technologies for laser power transmissions are assessed. Feasible laser mission systems are set out. Components by wavelength are summarized. Feasible space to space laser power transmission systems are summarized. Space laser transmitter masses for 1 MW and 100 KW output power are summarized. N.W.

N82-19260*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ANALYTICAL PERFORMANCE PREDICTION FOR LARGE ANTENNAS

M. EL-RAHEB *In* NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 471-478 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The coupled free-free modes of the 55M LMSS antenna configuration are shown. They were determined using modal synthesis. Reflector modes clamped at the hub were calculated adopting the efficient cyclic symmetry technique. Similarly, clamped hub modes of the offset boom structure were calculated. The modes of the two substructures were then combined through the process of modal synthesis on the assumption that the interface at the hub structure is rigid thus satisfying statically determinate matching conditions. For attitude control purposes, only modes associated with symmetric components zero and one involve net motions of the center of gravity of the reflector. This condition restricts the set of admissible eigenfunctions for modal synthesis. Modes with symmetric components higher than one are excited only by forces acting on the ribs. These modes are totally uncoupled from the boom dynamics. T.M.

N82-19264*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

RADIO FREQUENCY VERIFICATION TASKS RELATED TO A MULTIPLE APERTURE REFLECTOR SYSTEM

T. G. CAMPBELL *In its* Large Space Systems Technol., Pt. 2, 1981 p 551-556 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The establishment of analytical methods for predicting the electromagnetic performance of multiple offset fed apertures for multiple beam large space antenna systems is highlighted. The development of experimental modeling techniques for verifying the analytical methods used in predicting the effects of surface

roughness (pillows), scattering, and aperture coupling on RF performance is discussed. T.M.

N82-19265*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

PRELIMINARY EXPERIMENTAL TEST RESULTS USING 35 GHZ OFFSET FED REFLECTOR SIMULATING SURFACE PILLOWS AND APERTURE CABLES

T. G. CAMPBELL and W. R. YOUNG *In its* Large Space Systems Technol., Pt. 2, 1981 p 557-582 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The effects caused by reflector surface pillows and aperture cables on RF performance were determined. The test uses models that were designed to be replicas of a quad aperture at the proper $F/D = 1.50$ as provided in the LSST point design. Separate pillow models were machined from solid aluminum sections that simulated the surface contour pillows but on an exaggerated basis. The worse case pillow heights $\lambda/20$ and $\lambda/5$ were machined onto the precision reflector. In addition to the pillow effects, the scattering effects of aperture (Hoop/Column cables) cables were determined. Therefore, simulated quartz and graphite cables were tested with the smooth, $\lambda/20$, and $\lambda/5$ reflector models. T.M.

N82-19266*# Martin Marietta Corp., Denver, Colo.

PRELIMINARY ANALYTICAL RESULTS USING SURFACE CURRENT INTEGRATION FOR PREDICTING EFFECTS OF SURFACE PILLOWS ON RF PERFORMANCE

C. E. FARRELL and D. A. STRANGE *In* NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 583-590 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

An overview of the fast integral RF evaluation (FIRE) program is presented. This program uses surface current integration to evaluate RF performance of antenna systems. It requires modeling of surfaces in X, Y, Z coordinates along equally spaced X and Y grids with Z in the focal direction. The far field contribution of each surface point includes the effects of the Z-component of surface current which is not included in the aperture integration technique. Because of this, surface current integration is the most effective and inclusive technique for predicting RF performance on non-ideal reflectors. Results obtained from use of the FIRE program and an aperture integration program to predict RF performance of a LSS antenna concept are presented. T.M.

N82-19267*# Harris Corp., Melbourne, Fla.

RF VERIFICATION TASKS UNDERWAY AT THE HARRIS CORPORATION FOR MULTIPLE APERTURE REFLECTOR SYSTEM

T. A. GUTWEIN *In* NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 591-604 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

Mesh effects on gain and patterns and adjacent aperture coupling effects for 'pie' and circular apertures are discussed. Wire effects for Harris model with Langley scale model results included for assessing D/ λ effects, and wire effects with adjacent aperture coupling were determined. Reflector surface distortion effects (pillows and manufacturing roughness) were studied. T.M.

N82-19268*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

DISTORTED REFLECTOR ANTENNA PERFORMANCE PREDICTION TECHNIQUE

M. C. BAILEY *In its* Large Space Systems Technol., Pt. 2, 1981 p 605-610 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The application of a 3-D curve-fit technique to the electromagnetic analysis of reflector antennas is presented. The reflector antennas are described by the coordinates of an irregular distribution of measured points on the reflector surface. The reflector antenna analysis method used to calculate radiation patterns is geometric-optics with aperture-integration since an

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efficient and accurate computer code was readily available for modification. T.M.

N82-19269*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

MEASUREMENT OF LOSSES OF MESH MEMBRANE MATERIAL FOR REFLECTOR APPLICATIONS WITH AN S-BAND RADIOMETER

H. J. C. BLUME *In its* Large Space Systems Technol., Pt. 2, 1981 p 611-620 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The spatial resolution, the frequency of revisits, and the accuracy requirements for the detection of Earth surface parameters from space force the satellite designers to consider large space structures for microwaves. Some Earth surface parameters are only detectable with radiometers. Because the large reflectors should be much lighter than solid and deployable reflectors, mesh membrane material is considered to be used as the reflector. It is essential to determine the emissivity of the reflecting material even when close to zero to estimate the accuracy of the radiometer measurement. An existing S-band radiometer was used to determine the loss of a 1 sq m pretensioned mesh first in a field experiment and later in a well shielded laboratory set-up. The models for retrieving the emissivity of the mesh are described in detail and the equivalent losses for different mesh positions were calculated. T.M.

N82-19270*# Harris Corp., Melbourne, Fla.

THE SUITABILITY OF MESH MEMBRANE MATERIAL FOR RADIOMETER REFLECTOR APPLICATIONS

W. F. CROSWELL *In* NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 621-630 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The standard measurement system used for evaluating the transmission properties of mesh used in deployable antennas is shown schematically. The system allows the rapid measurement of the transmissivity of mesh samples at a given incidence angle. The analysis has the advantage in that the effects of conductivity loss, junction impedance, and cross polarization can be treated. T.M.

N82-19273*# Martin Marietta Aerospace, Denver, Colo.

NEAR FIELD TESTING OF LARC MULTIPLE BEAM ANTENNA

G. J. LANG *In* NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 657-680 Mar. 1982 refs

Avail: NTIS HC A21/MF A01 CSCL 22B

Near field antenna measurements as an alternative to far field measurements are discussed. Most of the serious shortcomings of far field measurements can be alleviated using near field techniques. The near field data can be used as a direct diagnostic of antenna performance before the integration by the aperture which can make it difficult to isolate the cause of far field pattern anomalies. L.F.M.

N82-19279*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

LAND MOBILE SATELLITE SYSTEMS (LMSS): SINGLE APERTURE SYSTEM DESIGN

W. J. WEBER, III *In* NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 797-780 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The large size of the UHF antenna on the satellite provides two advantages with respect to the Land Mobile Satellite System design. It provides tremendous gain for both transmitting and receiving at the satellite and enables very simple, low power equipment in the mobile vehicle. The UHF antenna for this study was selected to have an aperture of 55 meters. This implies a beamwidth of roughly 0.45 degree and requires 87 beams to cover the continental United States. L.F.M.

N82-19280*# General Electric Co., Philadelphia, Pa. Space System Div.

QUAD APERTURE RF DEFINITION

P. FOLDES *In* NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 781-820 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22A

A single STS package 118 m diameter hoop/column antenna is capable of providing service for appr. 250,000 mobile users. The selected quad aperture configuration is able to provide at least 25 db C/I without cable blockage, column scatter, coupling between quad apertures, and tolerance effects. A feed can be designed which uses single polarized radiating elements while the overall system employs dual polarization. The quad aperture concept can eliminate the use of diplexers and their associated losses. The critical technology issues in the RF area include the design of the radiating elements, BFN, monolithic power amplifiers and receiver front end, tolerance control and packaging of the feed. L.F.M.

N82-20374# European Space Agency, Paris (France).

PROBLEMS WITH MOBILE SATELLITE COMMUNICATIONS

H. OETTL *In its* On Radio Frequencies in Aerospace (ESA-TT-704) p 58-74 Dec. 1981 refs Transl. into ENGLISH from "Beitraege zum Kolloq. 'Hochfrequenztech. in der Luft- u. Raumfahrt'", Rept. DFVLR-Mitt-80-10 DFVLR, Oberpfaffenhofen, West Germany, Jun. 1980

Avail: NTIS HC A06/MF A01; DFVLR, Cologne DM 21,80

Three aspects of satellite communication with mobile ground stations are examined: satellite transmission efficiency, suitable equipment for mobile units, and transmission media characteristics. Possibilities for large geostationary satellite structures, e.g., the Public Service Platform, a multibeam antenna, are considered. The equipment for the German experimental ship terminal is described. Transmission measurement results (1.5 GHz) at low elevation angles are emphasized. Atmospheric influences, multipath effects, and signal fading are analyzed for transmissions via ATS-6 and MARISAT satellites. Author (ESA)

06

ADVANCED MATERIALS

Includes matrix composites, polyimide films, thermal control coatings, bonding agents, antenna components, manufacturing techniques, and space environmental effects on materials.

A82-11842#

'THIN FOIL CELLS - A CHALLENGE FOR SPACE ARRAY DESIGNERS'

P. A. ILES and F. HO (Applied Solar Energy Corp., City of Industry, CA) *In*: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 3. New York, American Society of Mechanical Engineers, 1981, p. 2126-2128. refs

The present status of manufacturing, power output, and life expectancy of thin foil silicon cells (less than 50 micron thickness) is reviewed. Properties such as 14-15% efficiency, flexibility, light weight, radiation resistance, controllable absorptance, and area ranging from 4-25 sq cm are noted as favorable features, while the need for extra care in preparation, easy loss of a greater number of cells due to random cracking, and additional fabrication steps all add to costs. Lighter weight is a significant advantage in considerations for higher orbital placement, with present blanket thin cell packaging yielding from 50-330 W/lb. Further testing is necessary to show operational durability in thermal cycling and LEO radiation, and for radiation hardness against diffusion length degradation or resistivity changes in the semiconductor. Additional testing is also needed to verify successful deployment of the blanket arrays. Progress toward thinner cells (25 micron) with slightly less efficiency and toward dendritic web production are

mentioned as showing promise for further cost reductions.

M.S.K.

A82-12495

POWDER METALLURGY SUPERALLOYS - AEROSPACE MATERIALS FOR THE 1980'S; PROCEEDINGS OF THE CONFERENCE, ZURICH, SWITZERLAND, NOVEMBER 18-20, 1980. VOLUME 1

Shrewsbury, Salop, England, MPR Publishing Services, Ltd., 1980. 237 p.

The conference focused on the latest advances in the powder metallurgy of superalloys, including developments in powder production, consolidation, and shape-making techniques, and applications. Papers are presented on the novel aspects for high-quality metal powder production equipment, oxide dispersion strengthened materials by mechanical alloying, potential for PM superalloys in aero engine application, HIP systems for superalloys, and electron-beam welding of PM nickel-base superalloys. V.L.

A82-12510#

PROSPECTS FOR SPACE MATERIALS SCIENCES EXPERIMENTS

L. G. NAPOLITANO (Napoli, Università, Naples, Italy) In: International Scientific Conference on Space, 21st, Rome, Italy, March 25, 26, 1981, Proceedings. Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1981, p. 109-120. refs

Main elements of the ESA Microgravity Research Program are reviewed. Experimentation in materials, fluids, and life sciences comprise the bulk of scientific and industrial interest in space research. The U.S. (SPAR), West Germany (TEXUS), and Sweden are participating in the Sounding Rockets Program, which offers 6-8 min of microgravity for experimentation, while Japan is readying materials tests for the first scheduled Spacelab flight in 1985. Advantages and disadvantages of the program are discussed. The Fluid Physics Program is described in terms of flight opportunities, upgrading of multiuser facilities, and new multiuser facilities. Upgrading of the Fluid Physics Multiuser Facility is noted to eventually require a second facility, the development of which needs a long lead time. Additional measurement capabilities for pressure, disk temperature, forces and moments on end disks, electric fields, and surface and bulk liquid velocities are recommended, and new directions for research are indicated.

M.S.K.

A82-12511#

MICROGRAVITY - A VALUABLE TOOL FOR FUNDAMENTAL STUDIES IN METALLURGY AND GROWTH FROM THE LIQUID PHASE

J. J. FAVIER (Commissariat à l'Energie Atomique, Laboratoire d'Etude de la Solidification, Grenoble, France) In: International Scientific Conference on Space, 21st, Rome, Italy, March 25, 26, 1981, Proceedings. Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1981, p. 125-132. refs

Opportunities in metallurgy and crystal growth from the liquid phase in microgravity are presented. Diffusion and convection in the volume phase are discussed, noting the importance of convective forces in the Czochralski method. Interfacial phenomena are affected by growth kinetics during eutectic solidification and in semiconductor formation. Fundamental growth studies in microgravity would achieve good heat flow and solute control in the liquid phase, eliminate hydrodynamic instabilities that impose particular morphologies on destabilized interfaces, and offer an absence of thermal disturbances that entail modification of interfacial properties or masking of related phenomena. Advantages over earth surface capillary and magnetic field experimental methods are stressed. Experiment proposals for the first Spacelab mission, including eutectic solidification, solute redistribution on macro- and microscopic scales, and the liquid/solid interface stability during growth are described, with samples of results of preliminary work on board Salyut 6 provided.

M.S.K.

A82-12512#

THE BEHAVIOUR OF DISPERSED PARTICLES IN MOLTEN METAL MATRIX COMPOSITES

L. FROYEN and A. DERUYTTERE (Leuven, Katholieke Universiteit, Louven, Belgium) In: International Scientific Conference on Space, 21st, Rome, Italy, March 25, 26, 1981, Proceedings. Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1981, p. 133-142. refs

Experiments to determine the usefulness of Spacelab for studying the fabrication of metallic composite materials and the behavior of solid particles in liquid metal are described. By using the Isothermal Heating Facility, the suitability of a microgravity environment for casting the composites will be tested. Phenomena which affect direct casting of metallic composites in a gravitational field are discussed, and the importance of an extended ground program to define the Spacelab experiments is stressed. Early work with Al-Al₂O₃, Al-SiC, Cu-Al₂O₃, Cu-SiC, and Cu-W, and observations of skeleton formation and thixotropic behavior are reported. Experimentation with Al-SiC, Cu-SiC, and CuSiO₂ to study the interaction of solid particles with an advancing solidification front is described and further work is noted on determining the critical velocity as a function of morphology, size, surface, condition of the dispersoid, and interfacial energy. Finally, a description of the Spacelab experiments, the design of the crucible and the samples, their preparation, and the experimental procedures are given.

M.S.K.

A82-12513#

DISPERSION CHARACTERISTICS IN METAL BASE SINTERED MATERIAL AFTER MELTING AND SOLIDIFICATION AT DIFFERENT G-LEVELS

L. CASTELLANI, F. BARBIERI (Bologna, Università; CNR, Gruppo Nazionale di Struttura della Materia, Bologna, Italy), and P. GONDI (CNR, Gruppo Nazionale di Struttura della Materia, Bologna; Roma, Università, Rome, Italy) In: International Scientific Conference on Space, 21st, Rome, Italy, March 25, 26, 1981, Proceedings. Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1981, p. 143-152. refs

Analytic comparisons are made of the dispersion characteristics of particles in sintered metals on earth and in zero-g environment. Suspensions on earth are noted to be affected by segregation due to settling, coalescence, and repulsion from the solidification front. Zero-g conditions offer the possibility of broader ranges of dispersed material, i.e., more homogeneous distribution. Powder mixing, compacting, and sintering procedures have been studied on earth for comparisons with experiments on board Spacelab. Sample batches have been prepared to determine the effects of concentration, dimension and nature of the dispersed phase (Al₂O₃; SiO₂), dispersing matrix characteristics (Cu; Al), pore size and distribution, and nucleation effects of the dispersed phase (Ag-Cu, Cu-Ge alloys) in a 1-g environment. A description of experimental procedures and apparatus for Spacelab is given.

M.S.K.

A82-15576

MECHANICS OF AEROSPACE MATERIALS

A. NICA (Aeronautical Institute, Bucharest, Rumania) Amsterdam, Elsevier Scientific Publishing Co. (Materials Science Monographs. Volume 9), 1981. 346 p. refs \$68

A description is presented of the operating conditions and stresses imposed on aerospace materials, taking into account temperature levels, the surrounding medium, electric and magnetic fields, exposure to radiation and meteorites, mechanical stresses, thermal stresses, the influence of chemical factors, radiation effects, materials for aerospace vehicles, specific testing methods, and specific technologies. The structure and properties of materials are examined, giving attention to the structure of solids, an atomistic approach to the properties of materials, crystalline structures, structural imperfections, and the plastic deformation of polycrystalline materials. Other subjects investigated are related to rheological behavior, tribological behavior, creep, fracture, and fatigue. Questions concerning the reliability of aerospace

constructions are explored. Reliability concepts are considered along with the significant factors for reliability estimation, the theoretical concepts on sensitivity to cyclic loading, aspects of life prediction, the reliability of power plants, and trends of material development. G.R.

A82-16003

MATERIALS FOR THE REFLECTING SURFACES OF SPACE EXPANDABLE ANTENNAS [MATERIALY DLIA OTRAZHAIUSHCHIKH POVERKHNOSTEI KOSMICHESKIKH SKLADNYKH ANTENN /KSA/]
I. A. KISANOV, N. M. FEIZULLA, L. A. KUDRIAVIN, and V. A. ZAVARUEV. *Antenny*, no. 29, 1981, p. 20-25. In Russian. refs

A82-16192#

LABORATORY STUDY OF THE CHARGING OF SPACECRAFT MATERIALS

M. S. LEUNG and H. K. A. KAN (Aerospace Corp., Chemistry and Physics Laboratory, El Segundo, CA) *Journal of Spacecraft and Rockets*, vol. 18, Nov.-Dec. 1981, p. 510-514. refs
(Contract F04701-78-C-0079)

Charging profiles of typical spacecraft materials received from the Satellite Surface Potential Monitor experiment aboard the P78-2 satellite show a number of interesting as well as unexpected features. During the natural charging event on April 24, 1979, the Kapton sample was charged to a voltage significantly lower than that of the Teflon sample, whereas earlier test results showed they should be comparable. At the same time, also contrary to previous ground measurements, the quartz fabric sample acquired a surface potential up to several kilovolts instead of a few hundred volts normally observed in the laboratory. In order to resolve the differences observed between flight and ground measurements, a laboratory study has been carried out. Based on this study, these unexpected flight measurements can now be explained. (Author)

A82-17533* Lockheed Missiles and Space Co., Sunnyvale, Calif.

A UNIQUE APPROACH TO FABRICATING PRECISION SPACE STRUCTURES ELEMENTS

H. COHAN and R. R. JOHNSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) In: *Composite structures; Proceedings of the First International Conference*, Paisley, Scotland, September 16-18, 1981. London, Applied Science Publishers, 1981, p. 580-591.

(Contract NAS1-14887)

A procedure of fabricating graphite epoxy columns used in the assembly of large space platforms is described. The requirement for precise dimensional control led to a unique hot resin injection process. Dry, high modulus fiber is wound over a vertically mounted steam-heated mandrel. A steam-heated sleeve or caul is slipped over the wound mandrel and resin is injected and cured in place. Approximately 200 column elements have been fabricated using this efficient process. (Author)

A82-17772#

COMPARATIVE REVIEW OF SELECTED TECHNIQUES TO OBTAIN SPACE CONTAMINATION CHARACTERISTICS

J. A. MUSCARI (Martin Marietta Aerospace, Denver, CO) *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting*, 20th, Orlando, FL, Jan. 11-14, 1982, 10 p. refs
(AIAA PAPER 82-0080)

An important criterion in the selection process of nonmetallic materials for space applications is related to the contaminant generation characteristics of the material. Current methods for categorizing contaminant generation characteristics of nonmetallic materials are not satisfactory for the considered application. Thus the need exists for a generalized material contaminant characteristic test procedure which is compatible with current analytical tool technology. The ASTM E595-77 Test Method is critically evaluated. Attention is also given to dynamic thermogravimetry, quartz crystal microbalance thermogravimetry, a tapered element oscillating microbalance, aspects of space environment simulation, optical/thermal effects of collected volatile

condensable material, and a generic candidate test technique.

G.R.

A82-18288*# Joint Inst. for Advancement of Flight Sciences, Hampton, Va.

INFRARED SPECTROSCOPIC ANALYSIS OF THE EFFECTS OF SIMULATED SPACE RADIATION ON A POLYIMIDE

J. E. FERL (Joint Institute for Advancement of Flight Sciences, Hampton, VA) and E. R. LONG, JR. (NASA, Langley Research Center, Hampton, VA) (IEEE, U.S. Defense Nuclear Agency, NASA, and DOE, Annual Conference on Nuclear and Space Radiation Effects, 18th, Seattle, WA, July 21-24, 1981.) *IEEE Transactions on Nuclear Science*, vol. NS-28, Dec. 1981, p. 4119-4124. refs

Infrared spectroscopic techniques have been used to study the effects of electron radiation on the polyimide PMDA-p,p'-prime-ODA. The radiation exposures were made at various dose rates, for a total dose approximately equal to that for 30 years of exposure to electron radiation in geosynchronous earth orbit. At high dose rates the major effect was probably the formation of a polyisoimide or a charged quaternary amine, and at the low dose rates the effect was a reduction in the amount of aromatic ether linkage. In addition, the effects of dose rate for a small total dose were studied. Elevated temperatures occurred at high dose rates and were, in part, probably the cause of the radiation product. The data suggest that dose rates for accelerated simulations of the space environment should not exceed 100,000 rads/sec.

(Author)

A82-18799#

SOLAR-ARRAY RADIATION DAMAGE

R. L. CRABB (ESA, Spacecraft Power Supplies Div., Noordwijk, Netherlands) *ESA Bulletin*, n4. 28, Nov. 1981, p. 72-80.

Solar arrays have been designed to allow adequate spacecraft end-of-life performance requirements to be met. The estimated power loss due to proton and electron bombardment in the earth's Van Allen belts is allowed for by optimizing the solar cell design and its glass cover-slide shielding, and by increasing the active solar array area accordingly. Materials research and annealing studies hold the prospect of solving the basic silicon solar-cell radiation-damage problem, and overcoming associated mass and size penalties that would otherwise be imposed on future solar-array programs. D.L.G.

A82-19944

SPACE TECHNOLOGY REQUIREMENTS ON MATERIALS AND PROCESSES [LES EXIGENCES DE LA TECHNOLOGIE SPATIALE RELATIVES AUX MATERIAUX ET PROCEDES]

J. DAUPHIN (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) (European Space Agency, Symposium on the Space Technology Demand on Materials and Processes, Noordwijk, Netherlands, Nov. 10-12, 1981.) *L'Aeronautique et l'Astronautique*, no. 91, 1981, p. 39-46. In French. refs

Solutions and potential solutions to various problems of space technology are discussed in order to illustrate the principles of the selection, combination and modification of various conventional materials and fabrication processes to satisfy the criteria for utilization in space. Examples are drawn from ESA experience in preventing satellite contamination by the use of the proper materials for solar panel adhesives, lubricants, electronic coverings and coatings, heat conduction materials, thermoregulation materials, paints, quartz fabric, optical solar reflectors, and second surface mirrors. Attention is also given to the requirements of projected space stations with lifetimes on the order of 30 years with regard to advanced reinforced materials, reusable metallic structures, and materials aging. A.L.W.

A82-22123

GRAPHITE-FIBER-REINFORCED GLASS FOR SPACECRAFT APPLICATIONS

K. M. PREWO (United Technologies Research Center, East Hartford, CT) Composites Technology Review, vol. 3, Winter 1981, p. 152, 153. refs

The construction methods used and material characteristics achieved to date, in the development of graphite-fiber-reinforced glass for spacecraft applications requiring exceptional dimensional stability and high-temperature stability, are described. This class of composites is fabricated by pulling graphite fiber tows through an agitated slurry of fine glass powder, cutting them into segments, laying up the plies in the desired orientation in graphite tooling, and hot-press diffusion bonding the material. Thornel-300 and HMS graphite fibers are used to reinforce borosilicate glass matrices. As in the case of other fiber-reinforced composites, a stabilizing heat-treatment cycle can produce overall dimensional stability. Secondary fabrication procedures include the hot forming of hat-section shapes and joining by brazing. O.C.

A82-23308

WELDING IN SPACE [SVARKA V KOSMOSE]

V. F. LAPCHINSKII In: Welding in the USSR. Volume 2 (Svarka v SSSR. Volume 2). Moscow, Izdatel'stvo Nauka, 1981, p. 487-493. In Russian.

Experience with welding operations performed on Soviet space flights is reviewed. Particular consideration is given to space welding simulation experiments, and to the development of space welding equipment (e.g., welding guns) and techniques. B.J.

A82-27097#

SCATHA CONDUCTIVE SPACECRAFT MATERIALS DEVELOPMENT

W. L. LEHN (USAF, Materials Laboratory, Wright-Patterson AFB, OH) American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 20th, Orlando, FL, Jan. 11-14, 1982, 6 p. refs

(AIAA PAPER 82-0263)

The development of new or modified spacecraft materials that would limit, control, and/or prevent spacecraft charging was included as part of the cooperative, interdependent Air Force/NASA Spacecraft Charging/Spacecraft Charging at High Altitudes (SCATHA) program. Materials of interest included conductive polymers, paints, transparent films and coatings as well as fabric coatings and interweaves. The evaluation of materials charging/discharging properties in the laboratory as well as under simulated and actual space substorm charging conditions were included in the overall integrated SCATHA program. The results and status of these materials development investigations will be reviewed. (Author)

A82-27126

FIBROUS COMPOSITES IN STRUCTURAL DESIGN

E. M. LENOE, (ED.), D. W. OPLINGER, and J. J. BURKE (U.S. Army, Army Materials and Mechanics Research Center, Watertown, MA) New York, Plenum Press, 1980. 883 p \$85

Developments related to aircraft structures are discussed, taking into account composite aircraft structures, composite wing substructure technology on the AV-8B advanced aircraft, a preliminary design development AV-8B forward fuselage composite structure, a wing fuselage critical component development program, and the development of a preloaded hybrid advanced composite wing pivot fairing. Other topics considered are related to missile and space applications, crashworthiness, impact damage, postbuckling, dynamics response, and special design considerations. Attention is also given to laminate plate theories, edge effects, flaw growth, helicopter applications, composite joints, a reliability/durability analysis, environmental effects, the development of an advanced composite hydrofoil control flap, and advancements in composite material flywheels. G.R.

A82-27421* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

RADIATION EFFECTS ON FOUR POLYSULFONE FILMS

B. SANTOS and G. F. SYKES (NASA, Langley Research Center, Hampton, VA) In: Technology transfer; Proceedings of the Thirteenth National Technical Conference, Mount Pocono, PA, October 13-15, 1981. Azusa, CA, Society for the Advancement of Material and Process Engineering, 1981, p. 256-269. refs

The response of polysulfones to proton and electron radiation is evaluated by assessing the radiation durability of four selected sulfones, establishing radiation interaction mechanisms with the polymer chain, and determining the dependence of radiation durability on chemical structure. Chain scission appears to predominate at lower doses up to about 10 to the 9th rad, and past this threshold the second mechanism, crosslinking, seems to predominate. This is evidenced by the increase in modulus, glass transition temperature, and increased quantity of thermally stable residue at high temperatures. The variations of chemical structure of the polysulfones appear to have little effect on the response to radiation. D.L.G.

A82-27422

INFLUENCE OF SPACE ENVIRONMENT ON ADHESIVES

B. J. MULROY, JR. and Y. D. IZU (Lockheed Missiles and Space Co., Inc., Space Systems Div., Sunnyvale, CA) In: Technology transfer; Proceedings of the Thirteenth National Technical Conference, Mount Pocono, PA, October 13-15, 1981. Azusa, CA, Society for the Advancement of Material and Process Engineering, 1981, p. 270-279.

A study completed at LMSC concerning adhesives and processing and environmental effects on bi-material adherend bonding is presented. The study identified bonded-joint requirements for space vehicle hardware, adhesive and screened candidates, screened adherend surface pre-bond treatment, and bond strengths at elevated temperatures for selection of adhesive systems for long-term environmental exposures. The capability of selected adhesives to cure under various temperature-time schedules representative of design and manufacturing constraints is assessed, and selected adhesive/adherend bonded joints are evaluated after extended thermal-vacuum cycling exposure to simulated ten-year spacecraft orbital life space environments. D.L.G.

N82-11116*# TRW Defense and Space Systems Group, Redondo Beach, Calif. Mechanical Engineering Lab.

RADIATION TESTING OF COMPOSITE MATERIALS, IN SITU VERSUS EX SITU EFFECTS Final Report

R. M. KURLAND, J. F. THOMASSON, and W. C. BEGGS Nov. 1981 109 p refs

(Contract NAS1-15848)

(NASA-CR-3475; REPT-351710-6028-UT-01) Avail: NTIS HC

A06/MF A01 CSCL 11D

The effect of post irradiation test environments on tensile properties of representative advanced composite materials (T300/5208, T300/934, C6000/P1700) was investigated. Four ply (+ or - 45 deg/+ or - 45 deg) laminate tensile specimens were exposed in vacuum up to a bulk dose of 1 x 10 to the 10th power rads using a mono-energetic fluence of 700 keV electrons from a Van de Graaff accelerator. Post irradiation testing was performed while specimens were being irradiated (in situ data), in vacuum after cessation of irradiation (in vacuo data), and after exposure to air (ex situ data). Room temperature and elevated temperature effects were evaluated. The radiation induced changes to the tensile properties were small. Since the absolute changes in tensile properties were small, the existence of a post irradiation test environment effect was indeterminate. B.W.

N82-14217*# Mission Research Corp., San Diego, Calif.

CHARGING AND DISCHARGING TEFLON

B. C. PASSENHEIM and V. A. J. VANLINT *In* NASA. Lewis Research Center Spacecraft Charging Technol., 1980 p 52-64 Oct. 1981 refs

(Contract DNA001-78-C-0269; F29601-78-C-0012)

Avail: NTIS HC A99/MF A01 CSCL 22B

The charging and discharging characteristics of several common satellite materials exposed to 0-30KV electrons are measured. Teflon is discussed because the charging characteristics are radically altered immediately after a spontaneous discharge. The exterior geometry of the test structure is shown. In all cases dielectric samples were 82 cm in diameter mounted on the front of a 120 cm diameter cylinder supported on an 85 cm, 0.95 cm thick plexiglass disc. Dielectric materials investigated were: back surface aluminized Kapton, back surface silvered Teflon, silicon alkyd white thermal control paint, and 50 cm by 50 cm array of 0.030 cm thick MgF2 coated fused silica solar cell cover slips.

S.L.

N82-14221*# United Kingdom Atomic Energy Authority, Harwell (England).

ELECTROSTATIC DISCHARGING BEHAVIOUR OF KAPTON IRRADIATED WITH ELECTRONS

D. VERDIN *In* NASA. Lewis Research Center Spacecraft Charging Technol., 1980 p 96-114 Oct. 1981 refs Sponsored by RAE

Avail: NTIS HC A99/MF A01 CSCL 22B

The electrostatic charging and discharging of Kapton when irradiated with monoenergetic electrons of 5 to 30 keV energy were studied. The leakage currents and rates of discharging always increased with the incident electron energy and flux, whereas the surface voltage showed a more complex behavior depending on the thickness of the material: for the thinner films it exhibited a maximum and then fell at higher energies. The surface voltage, the rate of discharging, and the peak current and total charge flow during a discharge were enhanced as the temperature was decreased from 70 C to -180 C, and were accompanied by a decreasing leakage current. Visible light or the presence of an aluminum coating on the irradiated surface caused reductions in the surface voltage and changes in the discharging characteristics. The results are discussed in terms of the leakage currents and the secondary emission of electrons. Photomicrographs taken after irradiation, and photographs of samples during irradiation, show good correlations between the positions of light flashes and of pinholes produced by the discharge arcs.

S.L.

N82-14226*# Case Western Reserve Univ., Cleveland, Ohio.

SECONDARY ELECTRON EMISSION YIELDS

I. KRAINSKY, W. LUNDIN, W. L. GORDON, and R. W. HOFFMAN *In* NASA. Lewis Research Center Spacecraft Charging Technol., 1980 p 179-197 Oct. 1981 refs (Contract NSG-3197)

Avail: NTIS HC A99/MF A01 CSCL 22B

The secondary electron emission (SEE) characteristics for a variety of spacecraft materials were determined under UHV conditions using a commercial double pass CMA which permits sequential Auger electron spectroscopic analysis of the surface. The transparent conductive coating indium tin oxide (ITO) was examined on Kapton and borosilicate glass and indium oxide on FED Teflon. The total SEE coefficient ranges from 2.5 to 2.6 on as-received surfaces and from 1.5 to 1.6 on Ar(+) sputtered surfaces with 5 nm removed. A cylindrical sample carousel provides normal incidence of the primary beam as well as a multiple Faraday cup measurement of the approximately nA beam currents. Total and true secondary yields are obtained from target current measurements with biasing of the carousel. A primary beam pulsed mode to reduce electron beam dosage and minimize charging of insulating coatings was applied to Mg/F2 coated solar cell covers. Electron beam effects on ITO were found quite important at the current densities necessary to do Auger studies.

M.D.K.

N82-14230*# European Space Research and Technology Center, Noordwijk (Netherlands).

MATERIALS CHARACTERIZATION STUDY OF CONDUCTIVE FLEXIBLE SECOND SURFACE MIRRORS

F. LEVADOU, S. J. BOSMA, and A. PAILLOUS (DERTS) *In* NASA. Lewis Research Center Spacecraft Charging Technol., 1980 p 237-260 Oct. 1981 refs

Avail: NTIS HC A99/MF A01 CSCL 22B

The status of prequalification and qualification work on conductive flexible second surface mirrors is described. The basic material is FEP Teflon with either aluminium or silver vacuum deposited reflectors. The top layer has been made conductive by deposition of layer of a indium oxide. The results of a prequalification program comprised of decontamination, humidity, thermal cycling, thermal shock and vibration tests are presented. Thermo-optical and electrical properties. The results of a prequalification program comprised of decontamination, humidity, thermal cycling, thermal shock and vibration tests are presented. Thermo-optical and electrical properties, the electrostatic behavior of the materials under simulated substorm environment and electrical conductivity at low temperatures are characterized. The effects of simulated ultra violet and particles irradiation on electrical and thermo-optical properties of the materials are also presented.

M.D.K.

N82-14232*# General Electric Co., Fairfield, Conn.

CHARGING CONTROL TECHNIQUES

R. E. SCHMIDT *In* NASA. Lewis Research Center Spacecraft Charging Technol., 1980 p 267-286 Oct. 1981 refs (Contract F33615-78-C-5119)

Avail: NTIS HC A99/MF A01 CSCL 22B

Transparent conductive thin films of indium oxide and indium-tin oxide were evaluated for their properties to control charge buildup on satellite materials. Both oxide coatings were evaluated for their uniformity, stability, reproducibility and characteristics on various substrate materials such as FEP Teflon, Kapton, and glass. The process development toward optimization and characterization of these thin semiconductor oxide coatings and the evaluation on large sizes performed for qualification for use on thermal control satellite materials is described. The materials have been characterized in multiple energy electron plasma environment and at low temperatures. All radiation measurements of the coatings under simulated substorm conditions have exhibited the characteristics of stable charge control. Measurement of surface potential during and after irradiation by electrons up to 30 KeV and ionizing gamma radiation show an effective stable grounding surface.

M.D.K.

N82-14243*# Aerospace Corp., El Segundo, Calif.

P78-2 ENGINEERING OVERVIEW

A. L. VAMPOLA *In* NASA. Lewis Research Center Spacecraft Charging Technol., 1980 p 439-460 Oct. 1980 refs (Contract F04701-80-C-0080)

Avail: NTIS HC A99/MF A01 CSCL 22B

Data from the P78-2 spacecraft are being used in verifying and validating analytical tools being developed for the design of spacecraft, such as NASCAP, for updating Military Standard 1541, for investigation of materials contamination, and for a study of the physics of charging. The analysis of this data has already resulted in changes in laboratory testing procedures, in a better understanding of some properties of materials exposed to the space environment, and in some insight into the EMI caused by discharges on spacecraft in a plasma environment. Some examples of early results from the engineering experiments are presented.

Author

N82-14286*# Boeing Aerospace Co., Seattle, Wash.
DESIGN, FABRICATION AND TEST OF GRAPHITE/POLYIMIDE COMPOSITE JOINTS AND ATTACHMENTS FOR ADVANCED AEROSPACE VEHICLES *Quarterly Technical Progress Report*, 1 Dec. 1980 - 31 Mar. 1981

J. B. CUSHMAN Hampton, Va. NASA. Langley Research Center. Apr. 1981 47 p refs
 (Contract NAS1-15644)
 (NASA-CR-159114; QTPR-7) Avail: NTIS HC A03/MF A01 CSCL 11D

Standard and advanced bonded joint concepts were evaluated to develop a data base for the design and analysis of advanced composite joints for use at elevated temperatures (561K (550F)). Design concepts for specific joint applications and the fundamental parameters controlling the static strength characteristics of such joints were identified. Test results are presented for rail shear and sandwich beam compression tests and tension tests of moisture conditioned specimens and bonded on 'T' sections. Coefficients of thermal expansion data are presented for A7F (LARC 13 Amide-imide modified) adhesion. Static discriminator test results for type 1 and type 2 bonded and bolted preliminary attachment concepts are presented and discussed. A.R.H.

N82-15088# Bundesanstalt fuer Materialpruefung, Berlin (West Germany).

PREPARATION, IMPLEMENTATION AND EVALUATION OF MATERIAL SCIENCE EXPERIMENTS UNDER THE SLN PROGRAM TEXUS 2 *Final Report*, Jan. 1980

H. SCHLECKER and P. SZIMKOWIAK Bonn Bundesministerium fuer Forschung und Technologie Aug. 1981 44 p refs In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie Prepared in cooperation with Technische Hochschule, Vienna
 (BMFT-FB-W-81-033; ISSN-0170-1339) Avail: NTIS HC A03/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 9,25

In order to evaluate the effects of microgravity on vacuum brazing and the phenomena involved (i.e., flow of braze metal, joint filling, microstructure), an experiment was performed in the isothermal heating furnace of the TEXUS II sounding rocket. The specimen, consisting of four Ni-cylinders inserted one inside the other to form a 200 um cylindrical gap and a 0-2000 um sickle-shaped gap, was brazed with a near eutectic Ag-Cu alloy. This brazing alloy contained a small amount of Li to promote spreading (58 Ag: 39 Cu: 3 Li at. pct), and radioactive ¹¹⁰m Ag as tracer metal. The specimen was evaluated by X-ray radiography, autoradiography and metallographic techniques. This experiment was carried out in preparation of the FSLP-experiment ES 304/ES 305. Author

N82-15090# Technische Universitaet, Munich (West Germany). Lehrstuhl fuer Raumfahrttechnik.

INVESTIGATIONS OF MICROMETEORITE IMPACTS ON LARGE SURFACES AND DURING LONG-TERM MISSIONS [UNTERSUCHUNGEN VON MIKROMETEORITENEINSCHLAGEN IN GROSSEN FLAECHEEN UND BEI LANGZEITMISSIONEN]

E. IGENBERGS and H. FECHTIG (Max-Planck Inst. fuer Kernphysik) Oct. 1980 73 p refs In GERMAN Sponsored by Bundesministerium fuer Forschung und Technologie (TUM-RT-TB-80/12) Avail: NTIS HC A04/MF A01

The number of dust particle impacts expected during space missions was investigated and a long-term experiment is presented in order to study the suitability of Spacelab as a micrometeorite detector. A detailed inventory was made of available information on the dust environment. The dust particle expectancy values are given for several planetary and interplanetary missions mentioned in the Lunar and Planetary Mission Handbook. The heat shield surface of Spacelab modules is not suited for micrometeorite detection due to the relatively short flight time. An experiment is proposed for the second mission of the Long Duration Exposure Facility. This experiment is to obtain information on the dust environment close to the Earth and is to contribute to the

development of interplanetary dust measuring devices.

Author (ESA)

N82-15093# Hochschule der Bundeswehr, Hamburg (West Germany). Lab. fuer Werkstoffkunde und Schweissttechnik.

INVESTIGATIONS ON THE INFLUENCE OF GRAVITY ON JOINING PROCESSES WITH LIQUID MELTS, AND OF BRAZING AND WELDING EXPERIMENTS UNDER WEIGHTLESSNESS *Final Report*, Jul. 1980

H. HOFFMEISTER and J. RUEDIGER Bonn Bundesministerium fuer Forschung und Technologie Jun. 1981 94 p refs In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie (BMFT-FB-W-81-024; ISSN-0170-1339) Avail: NTIS HC A05/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 19,75

Physical mechanisms in welding and brazing likely to be affected by space conditions are considered and the literature on actual space experiments is reviewed. Proposed Spacelab test experiments and complementary testing on Earth are described. Further development needs are identified in arc welding. It is proposed to analyze the influence of gravity on material transfer, on the shape and structure of seam, and on the segregation of the phases by: (1) taking advantage of rotary motions on Earth in order to raise the g level or to create short time weightlessness; (2) working in an aircraft or rocket under longer microgravity conditions; and (3) performing arc-spot welding in a vacuum so as to develop this process for use in space. Author (ESA)

N82-15127# Engins Matra, Velizy (France).

STUDY AND DEVELOPMENT OF HIGH STRENGTH COMPOSITE MATERIAL STRUCTURES BY THE THERMOMECHANICAL DEPARTMENT OF THE SPACE DIVISION OF MATRA [ETUDES ET DEVELOPPEMENT DE STRUCTURES EN MATERIAUX COMPOSITES A HAUTES CARACTERISTIQUES REALISEES PAR LE DEPARTEMENT MECANIQUE ET THERMIQUE DE MATRA DIVISION ESPACE]

J. P. ALLARD /n COMELIN Groupe Matra Composites Conf. 26 p 1981 In FRENCH
 Avail: NTIS HC A06/MF A01

Equipment structures were developed, using fiber reinforced composite materials with elevated mechanical characteristics and low coefficients of thermal expansion. Structures for the Ariane launch vehicle nose cone, for an optical measuring device, and for the SPOT satellite sensor are discussed. Design problems linked to materials used in space structures are identified. Composite materials are compared with metals. Results illustrate material selection criteria in terms of low weight and high rigidity. Dimensional stability is expressed as a function of the coefficient of thermal expansion. Examples of composite assemblies (riveted; bolted; tongue in groove) are shown. Author (ESA)

N82-17267*# North Carolina State Univ., Raleigh.

EFFECTS OF HIGH ENERGY RADIATION ON THE MECHANICAL PROPERTIES OF EPOXY/GRAPHITE FIBER COMPOSITES *Status Report*, 1 Jan. - 31 Dec. 1981

R. E. FORNES and J. D. MEMORY 31 Dec. 1981 121 p refs (Contract NSG-1562-S4)
 (NASA-CR-168421) Avail: NTIS HC A06/MF A01 CSCL 11D

Studies on the effects of high energy radiation on graphite fiber reinforced composites are summarized. Studies of T300/5208 and C6000/PMR15 composites, T300 fibers and the resin system MY720/DDS (tetraglycidyl-4,4'-diaminodiphenyl methane cured with diaminodiphenyl sulfone) are included. Radiation dose levels up to 8000 Mrads were obtained with no deleterious effects on the breaking stress or modulus. The effects on the structure and morphology were investigated using mechanical tests, electron spin resonance, X-ray diffraction, and electron spectroscopy for chemical analysis (ESCA or X-ray photoelectron spectroscopy). Details of the experiments and results are given. Studies of the fracture surfaces of irradiated samples were studied with scanning electron microscopy; current results indicate no differences in the morphology of irradiated and control samples. M.D.K.

N82-18276*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. Material Div.
THE EFFECTS OF ELECTRON AND GAMMA RADIATION ON EPOXY-BASED MATERIALS

R. E. FORNES, J. D. MEMORY, R. D. GILBERT, and E. R. LONG, JR. *In its Large Space Systems Technol.*, 1981 p 27-36 Mar. 1982 Prepared in cooperation with North Carolina State Univ., Raleigh

Avail: NTIS HC A19/MF A01 CSCL 22B

Specimens of graphite/epoxy composites and epoxy resins were exposed to electron and gamma radiation, followed by mechanical property and fundamental measurements. Measurement techniques included: scanning electron microscopy, X-ray diffraction analysis, and electron spin resonance spectroscopic analysis. Results indicate little or no change in flexural properties of miniature specimens of a graphite/epoxy composite and no change in failure mode at the fiber-resin interface and in the crystallinity of the fiber and the resin. Some doubt in the observation of stable flexural properties is cast by electron paramagnetic resonance spectra of a relatively large number of radiation-generated radicals. These generally lead to a change in cross-linking and in chain-scissioning which should alter mechanical properties.

J.M.S.

N82-18277*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

BASIC PHYSICAL AND CHEMICAL PROCESSES IN SPACE RADIATION EFFECTS ON POLYMERS

E. KAMARATOS, J. W. WILSON, C. K. CHANG, and Y. J. XU *In its Large Space Systems Technol.*, 1981 p 37-58 Mar. 1982 refs Prepared in cooperation with Christopher Newport College and Old Dominion Univ.

Avail: NTIS HC A19/MF A01 CSCL 22B

The effects of space ionizing radiation on polymers is investigated in terms of operative physical and chemical processes. A useful model of charged particle impact with a polymer was designed. Principle paths of molecular relaxation were identified and energy handling processes were considered. The focus of the study was on energy absorption and the immediately following events. Further study of the radiation degradation of polymers is suggested.

M.D.K.

N82-18278*# Jet Propulsion Lab., California Inst. of Tech., Pasadena. Energy and Materials Research Section.

PULSED RADIOLYSIS OF MODEL AROMATIC POLYMERS AND EPOXY BASED MATRIX MATERIALS

A. GUPTA, J. MOACANIN, R. LIANG, and D. COULTER *In NASA. Langley Research Center Large Space Systems Technol.*, 1981 p 59-65 Mar. 1982

Avail: NTIS HC A19/MF A01 CSCL 22B

Models of primary processes leading to deactivation of energy deposited by a pulse of high energy electrons were derived for epoxy matrix materials and poly(vinyl naphthalene). The basic conclusion is that recombination of initially formed charged states is complete within 1 nanosecond, and subsequent degradation chemistry is controlled by the reactivity of these excited states. Excited states in both systems form complexes with ground state molecules. These excimers or exciplexes have their characteristics emissive and absorptive properties and may decay to form separated pairs of ground state molecules, cross over to the triplet manifold or emit fluorescence. ESR studies and chemical analyses subsequent to pulse radiolysis were performed in order to estimate bond cleavage probabilities and net reaction rates. The energy deactivation models which were proposed to interpret these data have led to the development of radiation stabilization criteria for these systems.

Author

N82-18279*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

THE EFFECTS OF MICROCRACKING ON THE THERMAL EXPANSION OF GRAPHITE-EPOXY COMPOSITES

D. E. BOWLES *In its Large Space Systems Technol.*, 1981 p 67-79 Mar. 1982 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

A study of the effects of thermal environment and microcracking in graphite epoxy composites was made. Research indicates that microcracking does affect the thermal expansion of composite laminates. The amount of reduction in thermal expansion was a function of the crack density. A maximum reduction of approximately 25% occurred in a quasi-isotropic specimen with a crack density of 2.05 mm⁻¹ in the 90 deg plies. Laminate analysis with appropriate reductions in E sub 2 and Alpha sub 2 of the damaged plies appears to be capable of modeling the observed

M.D.K.

N82-18280*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

THERMAL EXPANSION OF GRAPHITE-EPOXY BETWEEN 116 K AND 366 K

J. S. SHORT, M. W. HYER, D. E. BOWLES, and S. S. TOMPKINS *In its Large Space Systems Technol.*, 1981 p 81-92 Mar. 1982 refs Prepared in cooperation with Virginia Polytechnic Institute and State Univ.

Avail: NTIS HC A19/MF A01 CSCL 22B

A Priest laser interferometer was developed to measure the thermal strain of composite laminates. The salient features of this interferometer are that: (1) it operates between 116 K and 366 K; (2) it is easy to operate; (3) minimum specimen preparation is required; (4) coefficients of thermal expansion in the range of 0-5 micro epsilon/K can be measured; and (5) the resolution of thermal strain is on the order of micro epsilon. The thermal response of quasi-isotropic, T300/5208, graphite-epoxy composite material was studied with this interferometer. The study showed that: (1) for the material tested, thermal cycling effects are negligible; (2) variability of thermal response from specimen to specimen may become significant at cryogenic temperatures; and (3) the thermal response of 0.6 cm and 2.5 cm wide specimens are the same above room temperature.

M.D.K.

N82-19969*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

PRELIMINARY ANALYSIS OF ACCELERATED SPACE FLIGHT IONIZING RADIATION TESTING

J. W. WILSON, L. V. STOCK (Old Dominion Univ.), D. J. CARTER, and C. K. CHANG (Christopher Newport Coll.) Jan. 1982 19 p refs

(NASA-TM-83209) Avail: NTIS HC A02/MF A01 CSCL 03B

A preliminary analysis shows that radiation dose equivalent to 30 years in the geosynchronous environment can be accumulated in a typical composite material exposed to space for 2 years or less onboard a spacecraft orbiting from perigee of 300 km out to the peak of the inner electron belt (approximately 2750 km). Future work to determine spacecraft orbits better tailored to materials accelerated testing is indicated. It is predicted that a range of 10 to the 9th power to 10 to the 10th power rads would be accumulated in 3-6 mil thick epoxy/graphite exposed by a test spacecraft orbiting in the inner electron belt. This dose is equivalent to the accumulated dose that this material would be expected to have after 30 years in a geosynchronous orbit. It is anticipated that material specimens would be brought back to Earth after 2 years in the radiation environment so that space radiation effects on materials could be analyzed by laboratory methods.

A.R.H.

07

ASSEMBLY CONCEPTS

Includes automated manipulator techniques, EVA, robot assembly, teleoperators, and equipment installation.

A82-14367* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ROBOTS AND MANIPULATORS

E. HEER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) Mechanical Engineering, vol. 103, Nov. 1981, p. 42-49.

Robots are defined and described for various applications. The key feature of robots is programmability, which allows teleoperation, repair work in hazardous situations, and unsupervised operation in industrial functions. Two types of robots now exist: special purpose, with equipment for a specific task; and general purpose, which include nonservo-controlled robots, servo-controlled robots, and sensory control robots. Sensory robots are the most sophisticated, and are equipped with both internal control sensors and external sensors such as TV cameras, pressure detectors, laser range finders, etc. Sensory feedback to a central computer enables the robots to make appropriate modifications to the control program to adapt to new situations. Pattern recognition and scans for size are features of the TV sensors, and programs to develop a universal effector (hand) are outlined. Finally, robot programming in terms of manual, walkthrough, and textual methods are described, and the potential uses of robots for space and undersea construction and repair are discussed. M.S.K.

A82-20772#

WORKING IN SPACE

G. V. BUTLER (McDonnell Douglas Astronautics Co., Huntington Beach, CA) Research sponsored by the American Institute of Aeronautics and Astronautics. New York, American Institute of Aeronautics and Astronautics, 1981. 134 p. refs
MEMBERS, \$20; NONMEMBERS, \$24

The developing capability of human beings to work in space are examined, with consideration given to the lessons learned from previous U.S. and Soviet space missions. Noting the innovative measures taken by the crewmembers of the Apollo 13 flight to avert disaster, the equipment and procedures for spending extended periods of time in space which were developed and tested during the Skylab and Salyut missions are reviewed. Repairs were effected on the Skylab solar panels and psychological and physical requirements were defined, as were spacecraft re-entry profiles when the Skylab finally came down. The functions and the experimental packages designed for the Space Shuttle are described, with particular attention given to the equipment intended to provide a greater range of activity and usefulness for space activities. Finally, projections are made for future, expanded space missions, including the construction of large space structures, the use of manned orbit transfer vehicles, and the colonization of space and the moon. M.S.K.

A82-22918* Essex Corp., Huntsville, Ala.

THE ASSEMBLY OF LARGE STRUCTURES IN SPACE - AN EVALUATION OF HARDWARE CONFIGURATIONS AND ASSEMBLY TECHNIQUES THROUGH NEUTRAL BUOYANCY SIMULATION

T. E. LOUGHEAD and E. C. PRUETT (Essex Corp., Huntsville, AL) In: Human Factors Society, Annual Meeting, 24th, Los Angeles, CA, October 13-17, 1980, Proceedings. Santa Monica, CA, Human Factors Society, Inc., 1980, p. 205-208. (Contract NAS8-32989)

The implementation of NASA's Space Transportation System (STS) presents the opportunity for the on-orbit assembly of structures which, before the advent of multi-launch missions, were not possible because of their physical size. This report presents the results of an eight-month effort in the investigation of assembly

techniques and hardware configurations used in assembly of the basic tetrahedral cell by A7LB pressure-suited subjects in Marshall Space Flight Center's Neutral Buoyancy Simulator. Eleven subjects participated in assembly procedures which investigated two types of structural members and two configurations of attachment hardware. The assembly was accomplished through extra-vehicular activity (EVA) only, EVA with simulated manned maneuvering unit (MMU), and EVA with simulated MMU and simulated remote manipulator system (RMS). Assembly times as low as 10.20 minutes per tetrahedron were achieved. (Author)

A82-22920* Lockheed Missiles and Space Co., Sunnyvale, Calif.

SPACE TELESCOPE - DESIGN FOR ORBITAL MAINTENANCE

H. T. FISHER (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) In: Human Factors Society, Annual Meeting, 24th, Los Angeles, CA, October 13-17, 1980, Proceedings. Santa Monica, CA, Human Factors Society, Inc., 1980, p. 214-218. (Contract NAS8-32697)

Maintenance and repair of the Shuttle launched Space Telescope (ST) are examined, noting that except for the basic structure, mirrors, cables, and several noncritical items, the entire ST is replaceable or repairable on-orbit. EVA tasks have been designed to avoid contamination, and to provide a reduction in Orbital Replacement Units, a minimal number of doors and openings, and minimized structural weight associated with free-volume. All removable components have been provided with tool-compatible fittings and releases, and standardization of parts has been compromised with considerations of interface with crew handling. Replacement and repair equipment will be carried as an added parcel on Shuttle flights and are not part of the standard Shuttle components. The necessity of designing for crew-aid at ST workstations is suggested to provide sound data for the design of other space-based equipment. M.S.K.

N82-12092* Draper (Charles Stark) Lab., Inc., Cambridge, Mass.

STUDY TO DEFINE AN APPROACH FOR DEVELOPING A COMPUTER-BASED SYSTEM CAPABLE OF AUTOMATIC, UNATTENDED ASSEMBLY/DISASSEMBLY OF SPACECRAFT, PHASE 1 Final Report, 1 Jun. - 31 Dec. 1980

J. L. NEVINS, T. L. DEFAZIO, D. S. SELTZER, and D. E. WHITNEY 1981 37 p refs
(Contract NAS5-26187)

(NASA-CR-166740; R-1436) Avail: NTIS HC A03/MF A01 CSCL 22A

The initial set of requirements for additional studies necessary to implement a space-borne, computer-based work system capable of achieving assembly, disassembly, repair, or maintenance in space were developed. The specific functions required of a work system to perform repair and maintenance were discussed. Tasks and relevant technologies were identified and delineated. The interaction of spacecraft design and technology options, including a consideration of the strategic issues of repair versus retrieval-replacement or destruction by removal were considered along with the design tradeoffs for accomplishing each of the options. A concept system design and its accompanying experiment or test plan were discussed. R.J.F.

N82-18289* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

MOBILE WORK STATION CONCEPT FOR ASSEMBLY OF LARGE SPACE STRUCTURES (ZERO GRAVITY SIMULATION TESTS)

W. L. HEARD, JR., H. G. BUSH, R. E. WALLSOM, and J. K. JENSEN In: Large Space Systems Technol., 1981 p 193-204 Mar. 1982 refs Prepared in cooperation with Kentron International, Inc.

Avail: NTIS HC A19/MF A01 CSCL 22B

The concept presented is intended to enhance astronaut assembly of truss structure that is either too large or complex to fold for efficient Shuttle delivery to orbit. The potential of augmented astronaut assembly is illustrated by applying the result of the tests

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to a barebones assembly of a truss structure. If this structure were assembled from the same nestable struts that were used in the Mobile Work Station assembly tests, the spacecraft would be 55 meters in diameter and consist of about 500 struts. The struts could be packaged in less than 1/2% of the Shuttle cargo bay volume and would take up approximately 3% of the mass lift capability. They could be assembled in approximately four hours. This assembly concept for erectable structures is not only feasible, but could be used to significant economic advantage by permitting the superior packaging feature of erectable structures to be exploited and thereby reduce expensive Shuttle delivery flights.

T.M.

N82-18290*# Grumman Aerospace Corp., Bethpage, N.Y.

ORBITER BASED CONSTRUCTION EQUIPMENT

C. J. GOODWIN /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 205-217 Mar. 1982

Avail: NTIS HC A19/MF A01 CSCL 22B

Many orbiter based activities need equipment to hold a payload steady while it is being worked on. This work may be construction, updating, repair, services, check out, or refueling operations in preparation for return to Earth. The Handling and Positioning Aid (HPA) is intended for use as general purpose equipment. The HPA provides a wide choice of work station positions, both immediately above the orbiter cargo bay and beyond. It can act in a primary docking role and, if required, can assist actively in the berthing process. From an analysis of ten reference missions, it was determined that two types of HPA mobility are needed; a tilt table, which simply swings out of the cargo bay, pivoting about an athwartships y axis, and an articulated arm. Illustration of the aid are provided.

T.M.

N82-18298*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

A STUDY OF AUTONOMOUS RENDEZVOUS AND DOCKING SYSTEMS

J. D. MICHAEL /in NASA. Langley Research Center Large Space Systems Technol., 1981 p 335-344 Mar. 1982 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

An overview of activities in the automatic rendezvous and docking area is presented. A representative mission scenario is covered. A statement of the problem is made and the requirements for the extraction of relative attitude and position data are delineated. A systems block diagram is included and the integral functions which go to make up an autonomous docking system is described. A system was simulated, and the digital simulation is described along with some representative results of a system based a laser ranging device as the sensor. A television camera as the ranging sensor was also considered, one video based automatic docking scheme is discussed along with some representative results.

S.L.

N82-19240# Eurosat S.A., Geneva (Switzerland).

TELEOPERATION AND AUTOMATION: A SURVEY OF EUROPEAN EXPERTISE APPLICABLE TO DOCKING AND ASSEMBLY IN SPACE Final Report

M. PLANTIER, R. BODMER, J. B. LAGARDE, and C. MILLER Paris ESA May 1981 80 p refs

(Contract ESTEC-4402/80/NL-AK(SC))

(MP/PR/4905; ESA-CR(P)-1487) Avail: NTIS HC A05/MF A01

Academic and industrial R and D bodies were surveyed in order to assess European robotic and teleoperator technology capabilities. Sensors and control mechanisms are considered. The survey indicates that Europe could develop the facilities necessary for the automation of a large number of space stations. Computer hardware and software must be upgraded. More international cooperation is required to offset the advantages given to the U.S. and the USSR by their militarily subsidized research budgets.

Author (ESA)

N82-19282*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

STRUCTURAL ASSEMBLY DEMONSTRATION EXPERIMENT

J. W. STOKES /in NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 841-858 Mar. 1982 refs

Avail: NTIS HC A21/MF A01 CSCL 22B

The experiment is of an operational variety, designed to assess crew capability in Large Space System (LSS) assembly. The six Structural Assembly Demonstration Experiment objectives include: (1) the establishment of a quantitative correlation between LSS neutral buoyancy simulation and on-orbit assembly operations in order to enhance the validity of those assembly simulations; (2) the quantitative study of the capabilities and mechanics of human assembly in an Extravehicular Activity environment; (3) the further corroboration of the LSS Assembly Analysis cost algorithm through the obtainment of hard data base information; (4) the verification of LSS assembly techniques and timelessness, as well as the identification of crew imposed loads and assembly aid requirements and concepts; (5) verification of a Launch/Assembly Platform structure concept for other LSS missions; and (6) lastly, to advance thermal control concepts through a flexible heat pipe.

L.F.M.

08

PROPULSION

Includes propulsion concepts and designs utilizing solar sailing, solar electric, ion, and low thrust chemical concepts.

A82-18199* Princeton Univ., N. J.

MASS DRIVER REACTION ENGINE CHARACTERISTICS AND PERFORMANCE IN EARTH ORBITAL TRANSFER MISSIONS

W. R. SNOW and R. S. DUNBAR (Princeton University, Princeton, NJ) (U.S. Army Armaments Research and Development Command and Defense Advanced Research Projects Agency, Conference on Electromagnetic Guns and Launchers, San Diego, CA, Nov. 4-6, 1980.) IEEE Transactions on Magnetics, vol. MAG-18, Jan. 1982, p. 176-189. Research supported by the Space Studies Institute refs

(Contract NSG-3176)

Configurations of a typical mass driver reaction engine (MDRE) are presented and its use for delivery of payloads to geosynchronous orbit (GEO) from low earth orbit (LEO) is discussed. Basic rocket equations are developed for LEO to GEO round-trip missions using a single exhaust velocity. It is shown that exhaust velocities in the 5-10 km/sec range (specific impulse of 500-1000 sec) are well suited for mass drivers, minimizing the overall cost of missions. Payload delivery rate fractions show that there is little to be gained by stretching out LEO to GEO transfer times from 90 to 180 days. It therefore pays to use the shorter trip time, approximately doubling the amount of delivered payload during any fixed time of use of the MDRE.

V.L.

A82-25540

ELECTRIC PROPULSION OF SPACECRAFT

D. G. FEARN (Royal Aircraft Establishment, Space Dept., Farnborough, Hants., England) British Interplanetary Society, Journal (Space Chronicle), vol. 35, Apr. 1982, p. 156-166. refs

The paper discusses the merits of electric propulsion technology, explaining that the very high exhaust velocities attainable allow the propellant masses required for most missions to be drastically reduced. The various types of electric thruster are then described briefly. The most highly developed and potentially useful thruster, the Kaufman electron bombardment ion thruster, is covered in greater detail, with particular reference to the T5 device developed in the UK. Candidate missions are discussed, ranging from attitude and orbit control functions to the application of ion propulsion to the deployment of solar power

satellites. Important terrestrial applications of electric propulsion technology are also mentioned. (Author)

N82-11110*# Boeing Aerospace Co., Seattle, Wash.
STUDY OF ELECTRICAL AND CHEMICAL PROPULSION SYSTEMS FOR AUXILIARY PROPULSION OF LARGE SPACE SYSTEMS. VOLUME 1: EXECUTIVE SUMMARY

W. W. SMITH and J. P. CLARK Nov. 1981 35 p refs 2 Vol.
 (Contract NAS3-21952)
 (NASA-CR-165502-VOL-1; D180-25956-3-VOL-1) Avail: NTIS
 HC A03/MF A01 CSCL 21H

The objective was to determine the direction auxiliary propulsion research and development should take to best meet upcoming needs. The approach used was to define the important electrical and chemical propulsion characteristics in terms of the demands that will be imposed by future spacecraft. Comparison of these desired characteristics and capabilities with those presently available was then used to identify deficiencies. T.M.

N82-11111*# Boeing Aerospace Co., Seattle, Wash.
STUDY OF ELECTRICAL AND CHEMICAL PROPULSION SYSTEMS FOR AUXILIARY PROPULSION OF LARGE SPACE SYSTEMS, VOLUME 2 Final Report

W. W. SMITH Nov. 1981 540 p refs 2 Vol.
 (Contract NAS3-21952)
 (NASA-CR-165502-VOL-2; D180-2595-4-VOL-2) Avail: NTIS HC
 A23/MF A01 CSCL 21H

The five major tasks of the program are reported. Task 1 is a literature search followed by selection and definition of seven generic spacecraft classes. Task 2 covers the determination and description of important disturbance effects. Task 3 applies the disturbances to the generic spacecraft and adds maneuver and stationkeeping functions to define total auxiliary propulsion systems requirements for control. The important auxiliary propulsion system characteristics are identified and sensitivities to control functions and large space system characteristics determined. In Task 4, these sensitivities are quantified and the optimum auxiliary propulsion system characteristics determined. Task 5 compares the desired characteristics with those available for both electrical and chemical auxiliary propulsion systems to identify the directions technology advances should take. T.M.

N82-13427*# Aerojet Nuclear Systems Co., Sacramento, Calif.
LOW-THRUST CHEMICAL PROPULSION SYSTEM PUMP TECHNOLOGY Final Report

R. L. SABIERS and A. SIEBENHAAR Mar. 1981 201 p refs
 (Contract NAS3-21960)
 (NASA-CR-165219) Avail: NTIS HC A10/MF A01 CSCL 13K

Candidate pump and driver systems for low thrust cargo orbit transfer vehicle engines which deliver large space structures to geosynchronous equatorial orbit and beyond are evaluated. The pumps operate to 68 atmospheres (1000 psi) discharge pressure and flowrates suited to cryogenic engines using either LOX/methane or LOX/hydrogen propellants in thrust ranges from 445 to 8900 N (100 to 2000 lb F). Analysis of the various pumps and drivers indicate that the low specific speed requirement will make high fluid efficiencies difficult to achieve. As such, multiple stages are required. In addition, all pumps require inducer stages. The most attractive main pumps are the multistage centrifugal pumps. S.L.

N82-18584*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
LASER ROCKET SYSTEM ANALYSIS

In NASA. Langley Research Center Space Laser Power Transmission System Studies p 123-134 Feb. 1982 refs
 Avail: NTIS HC A10/MF A01 CSCL 20E

Potential national space transportation budget savings offered by laser rocket systems are considered. Orbital payload transportation costs, requiring 16 MW laser power space based or 37.5 MW ground based, are reduced by a factor of 2.4. The SPS orbital transportation costs, requiring 490 MW laser power space based or 1000 MW ground based, are reduced by factors

up to 7. Technology advancement is indicated for the laser, thruster, large lightweight adaptive mirror, and pointing and tracking. N.W.

09

FLIGHT EXPERIMENTS

Includes controlled experiments requiring high vacuum and zero G environment.

A82-11757*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

SEP SOLAR ARRAY SHUTTLE FLIGHT EXPERIMENT

R. V. ELMS, JR. (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), L. E. YOUNG, and H. C. HILL (NASA, Marshall Space Flight Center, Huntsville, AL) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 1. New York, American Society of Mechanical Engineers, 1981, p. 369-373.
 (Contract NAS8-31352)

An experiment to verify the operational performance of a full-scale Solar Electric Propulsion (SEP) solar array is described. Scheduled to fly on the Shuttle in 1983, the array will be deployed from the bay for ten orbits, with dynamic excitation to test the structural integrity being furnished by the Orbiter verniers; thermal, electrical, and sun orientation characteristics will be monitored, in addition to safety, reliability, and cost effective performance. The blanket, with aluminum and glass as solar cell mass simulators, is 4 by 32 m, with panels (each 0.38 by 4 m) hinged together; two live Si cell panels will be included. The panels are bonded to stiffened graphite-epoxy ribs and are storable in a box in the bay. The wing support structure is detailed, noting the option of releasing the wing into space by use of the Remote Manipulator System if the wing cannot be refolded. Procedures and equipment for monitoring the array behavior are outlined, and comprise both analog data and TV recording for later playback and analysis. The array wing experiment will also aid in developing measurement techniques for large structure dynamics in space. M.S.K.

N82-12094*# General Dynamics/Convair, San Diego, Calif.
 Advanced Space Programs.

SPACE CONSTRUCTION EXPERIMENT DEFINITION STUDY (SCEDS), PART 1. VOLUME 1: EXECUTIVE SUMMARY Final Report

1 Sep. 1981 34 p
 (Contract NAS9-16303)
 (NASA-CR-167458; GDC-ASP-81-009-VOL-1-PT-1; DRL-T-1346; DRD-MA-664T) Avail: NTIS HC A03/MF A01 CSCL 22A

Definition was completed on a basic flight experiment which will provide data on the construction of large space systems from the orbiter which could not be practicably obtained from ground tests. Dynamic behavior of a representative large structure was predicted. On-orbit construction operations were studied. Orbiter control during and after construction was investigated. Evolutionary or supplemental flight experiments for the development of augmentation of a basic flight experiment were identified and defined. R.J.F.

N82-12095*# General Dynamics/Convair, San Diego, Calif.
 Advanced Space Programs.

SPACE CONSTRUCTION EXPERIMENT DEFINITION STUDY (SCEDS), PART 1. VOLUME 2: STUDY RESULTS Final Report

1 Sep. 1981 149 p refs
 (Contract NAS9-16303)
 (NASA-CR-167432; GDC-ASP-81-010-VOL-2-PT-1; DRL-T-1346; DRD-MA-664T) Avail: NTIS HC A07/MF A01 CSCL 22B

A basic Space Shuttle flight experiment which will provide needed data on the construction of large space systems from the Orbiter was defined. The predicted dynamic behavior of a

09 FLIGHT EXPERIMENTS

representative large structure, on-orbit construction operations, and Orbiter control during and after construction were studied. Evolutionary or supplemental flight experiments for the development or augmentation of a basic flight experiment were identified and defined. The study was divided into six major tasks with appropriate sub-tasks noted. R.J.F.

N82-19283*# Massachusetts Inst. of Tech., Cambridge.
STRUCTURAL ASSEMBLY DEMONSTRATION EXPERIMENT (SADE) EXPERIMENT DESIGN

D. L. AKIN and M. L. BOWDEN /In NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 859-880 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The Structural Assembly Demonstration Experiment concept is to erect a hybrid deployed/assembled structure as an early space experiment in large space structures technology. The basic objectives can be broken down into three generic areas: (1) by performing assembly tasks both in space and in neutral buoyancy simulation, a mathematical basis will be found for the validity conditions of neutral buoyancy, thus enhancing the utility of water as a medium for simulation of weightlessness; (2) a data base will be established describing the capabilities and limitations of EVA crewmembers, including effects of such things as hardware size and crew restraints; and (3) experience of the M.I.T. Space Systems Lab in neutral buoyancy simulation of large space structures assembly indicates that the assembly procedure may create the largest loads that a structure will experience during its lifetime. Data obtained from the experiment will help establish an accurate loading model to aid designers of future space structures. L.F.M.

N82-19284*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SOLAR ARRAY FLIGHT EXPERIMENT (SAFE)

R. W. SCHOCK /In NASA. Langley Research Center Large Space Systems Technol., Pt. 2, 1981 p 881-891 Mar. 1982

Avail: NTIS HC A21/MF A01 CSCL 22B

The solar arrays flight experiment consists of four experiments on two different flights. The first experiment, termed the baseline, has a basic purpose to demonstrate the flight readiness of lightweight solar array technology for solar electric propulsion and other payload power applications. The early availability of this experiment and its basic large space structure characteristics make it a logical candidate to demonstrate other disciplines critical to large space structures. These demonstrations form the basis for three other solar array experiments, two in remote sensing and one in control. All of these experiments are briefly reviewed in this paper. L.F.M.

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GENERAL

Includes either state-of-the-art or advanced technology which may apply to Large Space Systems and does not fit within the previous categories. Publications of conferences, seminars, and workshops are covered in this area.

A82-11841#

REQUIREMENTS AND TECHNOLOGY TRENDS FOR FUTURE MILITARY SPACE POWER SYSTEMS

M. COHEN (Aerospace Corp., El Segundo, CA), E. FORNOLES (USAF, Space Div., El Segundo, CA), and T. MAHEFKEY (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) In: Intersociety Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1981, Proceedings. Volume 3. New York, American Society of Mechanical Engineers, 1981, p. 2122-2125. refs

Evolutionary and revolutionary changes considered necessary for satisfying increasing power requirements of military spacecraft are reviewed. Power usage is seen to expand in steps from 1-2 kW to 8 kW, 15 kW, then hundreds of kW, and finally into the MW range over the next 15 years. Applications include electrooptical and radar surveillance systems, laser communications satellites, space station defense against hostile action, transfer from LEO to GEO, and laser and directed energy weapons. The energy weapons systems would require advancements in energy storage capabilities because peak power exceeds nominal usage by 10-1000:1. Power per pound graphs are presented for nuclear and solar cell power systems, showing that nuclear systems have a 3-5:1 edge over solar systems; nuclear systems development over the next decade will, however, cost 5-10 times the amount necessary for solar development. Governing parameters will be reliability, survivability, volume, life cycle costs, availability, system weight, and risk factors. Stress is laid on the need for long lead time development to forestall revolutionary changes which require large power systems to maintain military capabilities. M.S.K.

A82-12501

INTERNATIONAL SCIENTIFIC CONFERENCE ON SPACE, 21ST, ROME, ITALY, MARCH 25, 26, 1981, PROCEEDINGS [CONVEGNO INTERNAZIONALE SCIENTIFICO SULLO SPAZIO, 21ST, ROME, ITALY, MARCH 25, 26, 1981, ATTI]

Conference sponsored by the Ministero degli Affari Esteri, Ministero della Difesa, CNR, et al. Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1981. 200 p. In Italian and English.

Papers are presented on solar power satellites and Spacelab technology. Topics covered include conversion and transmission techniques, safety problems, and structures and positioning in orbit. Attention is also given to cost considerations and energy balances for the SPS. Aspects of the first flight of Spacelab which were considered comprised scientific and technological experiments, material and life sciences, astronomy, plasma physics, and earth observations, experiment operation, and payload specialist training. M.S.K.

A82-12617

THE SPACE SHUTTLE - ITS CURRENT STATUS AND FUTURE IMPACT; PROCEEDINGS OF THE AEROSPACE CONGRESS AND EXPOSITION, LOS ANGELES, CA, OCTOBER 13-16, 1980 Warrendale, PA, Society of Automotive Engineers, Inc. (SAE Proceedings P-93), 1981. 91 p \$15

Papers dealing with various aspects of future applications and components of the Space Transportation System are covered. Specific topics include the Shuttle, an overview of the STS payload carriers, the Shuttle main engine development, and development and uses of the Multimission Modular Spacecraft. Also discussed are the Shuttle ground support systems at Vandenberg, application

of Gauss-Seidel multilevel control to a single axis torsional model, the impact of the STS on communication satellite design, advanced 30/20 GHz communication satellites, and structural modeling for control design of a large solar array. D.H.K.

A82-16338

INTERNATIONAL SPACE TECHNICAL APPLICATIONS; PROCEEDINGS OF THE NINETEENTH GODDARD MEMORIAL SYMPOSIUM, ARLINGTON, VA, MARCH 26, 27, 1981

A. ADELMAN, (ED.) (NASA, Goddard Space Flight Center, Greenbelt, MD) and P. BAINUM (Howard University, Washington, DC) Symposium sponsored by the AAS, ACS, AIAA, et al San Diego, CA, Univelt, Inc. (Science and Technology Series. Volume 52), 1981. 186 p
\$30

Topics discussed include industry in space, international Landsat programs, communications, weather and climate, space-based earth science applications, and space-based manufacturing and power generation. Papers are presented on space transportation in the private sector, the role of satellite remote sensing in climatology during the next 20 years, magnetic space-based field measurements, and energy for space applications. An assessment of domestic satellite communication technology is given, as is a forecast of the demand and capacity of U.S. domestic communications satellites. C.R.

A82-17976

INTERNATIONAL MICROWAVE SYMPOSIUM, LOS ANGELES, CA, JUNE 15-19, 1981, PROCEEDINGS

R. L. EISENHART, (ED.) (Hughes Aircraft Co., Culver City, CA) Symposium sponsored by the Institute of Electrical and Electronics Engineers and International Union of Radio Science. IEEE Transactions on Microwave Theory and Techniques, vol. MTT-29, Dec. 1981. 144 p.

Papers presented in this volume cover diverse areas related to microwaves, including semiconductor devices, medical applications, circuit design, propagation, field theory, power, surface acoustic waves, ferrites, and measurements. Papers are included on the hybrid mode analysis of microstrip lines on anisotropic substrates, horn image-guide leaky-wave antenna, status of the microwave power transmission components for the solar power satellites, and analysis of microstrip circuits coupled to dielectric resonators. V.L.

A82-18643

MACRO-ENGINEERING: THE RICH POTENTIAL; PROCEEDINGS OF THE THIRD SYMPOSIUM, SAN FRANCISCO, CA, JANUARY 6, 1980

R. SALKELD, (ED.) (System Development Corp., Santa Monica, CA), F. P. DAVIDSON, and C. L. MEADOR (MIT, Cambridge, MA) Symposium sponsored by the American Association for the Advancement of Science and American Institute of Aeronautics and Astronautics. New York, American Institute of Aeronautics and Astronautics, 1981. 186 p.

MEMBERS, \$19.; NONMEMBERS, \$24

After considering the relationship of large-scale enterprises to social attitudes and social change, attention is given to: (1) increasing the degree of communication between project-managers and clients in developing countries, (2) the creation of a public-service data utility, and (3) the development of the Great Recycling and Northern Development (GRAND) canal concept for water management on the North American continent. Also discussed are: (4) a solar thermal aerostat research station consisting of a large-diameter, solar-heated sphere capable of stratospheric stationkeeping, (5) a macroengineering solution to the macroproblem posed by the application of solar power satellites to the energy needs of India, (6) a multipurpose microwave space facility for the 1990s, and (7) the disposal of nuclear wastes in space. O.C.

A82-20876

SPACE IN THE 1980'S AND BEYOND; PROCEEDINGS OF THE SEVENTEENTH EUROPEAN SPACE SYMPOSIUM, LONDON, ENGLAND, JUNE 4-6, 1980

P. M. BAINUM, (ED.) (Howard University, Washington, DC) Symposium sponsored by the Association Aeronautique et Astronautique de France, Deutsche Gesellschaft fuer Luft- und Raumfahrt, American Astronautical Society, et al. San Diego, CA, American Astronautical Society (Science and Technology Series. Volume 53); Univelt, Inc., 1981. 302 p
\$40

Topics discussed include a long-term space program for Europe, space communications, space transportation, applications, and technology, and lunar and planetary exploration. Papers are presented on manufacturing in space, on the contributions of space reflector technology to food production, local weather manipulation, and energy supply, and on a technological approach towards future large solar arrays. Attention is also given to low-pressure greenhouses and plants for a manned research station on Mars, to the extraction of Martian resources for a manned research station, and to the development of future lunar exploration. C.R.

A82-24683

THE 1980'S - A FOREST OF ENERGY DECISION TREES; PROCEEDINGS OF THE REGION SIX CONFERENCE, SAN DIEGO, CA, FEBRUARY 20-22, 1980

Conference sponsored by the Institute of Electrical and Electronics Engineers. New York, Institute of Electrical and Electronics Engineers, Inc., 1980. 192 p.

MEMBERS, \$22.50; NONMEMBERS, \$30

Technical and economic problems were addressed for developing technologies which hold promise for replacing world demand for oil based fuels. Monitoring and analysis of conservation measures were discussed, along with new sources of fossil fuels, and energy from OTEC and fusion power plants. Geothermal plant siting, construction, and operation were examined, and MHD prototype plants were described. The applications and social effects of energy storage systems were explored, along with biomass potentials and methods, solar thermal energy systems, and topics relevant to fission reactor power systems. Finally, the development and assessment of fuel cells for commercial and utility applications were described, and IEEE position papers were presented on reactors, safety, cogeneration, SPS, and solid waste energy sources. M.S.K.

A82-27830#

LEGAL ASPECTS OF ECONOMIC ACTIVITIES OF STATES AND TECHNOLOGY TRANSFER TO OUTER SPACE

C. C. OKOLIE (World Without War Council, Chicago, IL) In: Colloquium on the Law of Outer Space, 24th, Rome, Italy, September 6-12, 1981, Proceedings. New York, American Institute of Aeronautics and Astronautics, 1982, p. 47-56. refs (IAF 81-SL-46)

The development of air sovereignty claims by governments is traced, noting the modifications which became necessary with the advent of remote sensing capabilities, and consideration is given to legal and jurisdictional issues raised by the Shuttle and the possibility of mining moon minerals. The controversy surrounding a legal definition of the Shuttle is reviewed, and pertinent liability legislation once applied to damage caused by balloon transportation is cited as precedent for regarding the Shuttle as a spacecraft when in orbit and an aircraft when in the landing phase. The U.S. is concluded to be liable for Shuttle activities, while goods carried on the Shuttle are also required to provide third-party insurance as well as the launch fee. The way for states without space capabilities to share in the Shuttle is shown to be investment in the Shuttle program in terms of remote sensing satellites, large space structures, and communications satellites. M.S.K.

10 GENERAL

A82-27831#

THE THIRD WORLD AND SPACE LAW

O. DE SAINT LAGER In: Colloquium on the Law of Outer Space, 24th, Rome, Italy, September 6-12, 1981, Proceedings. New York, American Institute of Aeronautics and Astronautics, 1982, p. 57-61.

(IAF 81-SL-05)

The impacts in space law of issues involving equality, sovereignty, and internationalization among the developing nations are examined. The main thrust of actions of developing nations during the writing of international treaties concerned with the world economic and legal order is defined as modifying the international order into an instrument of development. Outer space is noted to be limited so far only in terms of use of GEO and the division of the radio frequency spectrum. Controversies currently surround the dissemination of remotely sensed resources, the establishment of satellite television broadcasts, and the allocation of radio frequency bands to nations which can not at present use them. Overcrowding of space is demonstrated to be the only degradation which may result from large-scale space resource exploitation. Finally, it is noted that the free flow of information is more a factor of equality than one of domination. M.S.K.

A82-27848#

STATUS OF INTERNATIONAL ORGANISATIONS IN RESPECT OF INTERNATIONAL SPACE SYSTEMS

M. G. BOURELY In: Colloquium on the Law of Outer Space, 24th, Rome, Italy, September 6-12, 1981, Proceedings. New York, American Institute of Aeronautics and Astronautics, 1982, p. 169-172.

(IAF 81-SL-31)

The existing legal instruments and international organizations governing activities in space are reviewed with special reference to new legal issues which will emerge with the creation of large space systems. Such systems will include large orbital stations and space transportation systems and involve considerable expansion of such activities as telecommunications and remote mapping of earth resources as well as new activities such as manufacturing in space and establishment of solar power stations. It is suggested that a thorough study of the new legal issues is required in order to draw an international convention regulating these issues. V.L.

N82-12109*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SPACECRAFT DYNAMICS AS RELATED TO LABORATORY EXPERIMENTS IN SPACE

G. H. FICHTL, ed., B. N. ANTAR, ed., and F. G. COLLINS, ed. Nov. 1981 206 p refs Workshop held in Huntsville, Ala., 1-2 May 1979

(NASA-CP-2199; M-362) Avail: NTIS HC A10/MF A01 CSCL 22B

Proceedings are presented of a conference sponsored by the Physics and Chemistry Experiments in Space Working Group to discuss the scientific and engineering aspects involved in the design and performance of reduced to zero gravity experiments affected by spacecraft environments and dynamics. The dynamics of drops, geophysical fluids, and superfluid helium are considered as well as two phase flow, combustion, and heat transfer. Interactions between spacecraft motions and the atmospheric cloud physics laboratory experiments are also examined.

N82-12538*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

WORKSHOP ON MICROWAVE POWER TRANSMISSION AND RECEPTION. WORKSHOP PAPER SUMMARIES

1980 1366 p refs Workshop held in Houston, Tex., 15-18 Jan. 1980 Document contains eight bound supplements

(NASA-TM-84064) Avail: NTIS HC A99/MF A01 CSCL 10A

Microwave systems performance and phase control are discussed. Component design and reliability are highlighted. The power amplifiers, radiating elements, rectennas, and solid state

configurations are described. The proper sizing of microwave transmission systems is also discussed.

N82-14213*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SPACECRAFT CHARGING TECHNOLOGY, 1980

Washington Oct. 1981 1005 p refs Conf. held in Colorado Springs, 12-14 Nov. 1980; sponsored by AFGL and NASA Lewis Research Center

(NASA-CP-2182; AFGL-TR-81-0270) Avail: NTIS HC A99/MF A01 CSCL 22B

The third Spacecraft Charging Technology Conference proceedings contain 66 papers on the geosynchronous plasma environment, spacecraft modeling, charged particle environment interactions with spacecraft, spacecraft materials characterization, and satellite design and testing. The proceedings is a compilation of the state of the art of spacecraft charging and environmental interaction phenomena.

N82-14271*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AGREEMENT FOR NASA/OAST - USAF/AFSC SPACE INTERDEPENDENCY ON SPACECRAFT ENVIRONMENT INTERACTION

C. P. PIKE (AFGL) and N. J. STEVENS In: *its* Spacecraft Charging Technol., 1980 p 912-930 Oct. 1980 refs

Avail: NTIS HC A99/MF A01 CSCL 22B

A joint AF/NASA comprehensive program on spacecraft environment interactions consists of combined contractual and in house efforts aimed at understanding spacecraft environment interaction phenomena and relating ground test results to space conditions. Activities include: (1) a concerted effort to identify project related environmental interactions; (2) a materials investigation to measure the basic properties of materials and develop or modify materials as needed; and (3) a ground simulation investigation to evaluate basic plasma interaction phenomena and provide inputs to the analytical modeling investigation. Systems performance is evaluated by both ground tests and analysis. There is an environmental impact investigation to determine the effect of future large spacecraft on the charged particle environment. Space flight investigations are planned to verify the results. The products of this program are test standards and design guidelines which summarize the technology, specify test criteria, and provide techniques to minimize or eliminate system interactions with the charged particle environment. A.R.H.

N82-16147*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

ATS-6 ENGINEERING PERFORMANCE REPORT. VOLUME: PROGRAM AND SYSTEMS SUMMARIES: MECHANICAL AND THERMAL DETAILS Final Report

R. O. WALES, ed. Nov. 1981 272 p refs 6 Vol.

(Contract NAS5-25464)

(NASA-RP-1080-VOL-1; REPT-81F0034-VOL-1) Avail: NTIS HC A12/MF A01 CSCL 22B

The overall mission and spacecraft systems, testing, and operations are summarized. The mechanical subsystems are reviewed, encompassing mechanical design requirements; separation and deployment mechanisms; design and performance evaluation; and the television camera reflector monitor. Thermal control and contamination are discussed in terms of thermal control subsystems, design validation, subsystems performance, the advanced flight experiment, and the quartz-crystal microbalance contamination monitor. N.W.

N82-16148*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ATS-6 ENGINEERING PERFORMANCE REPORT. VOLUME 2: ORBIT AND ATTITUDE CONTROLS Final Report
 R. O. WALES, ed. Nov. 1981 289 p refs 6 Vol.
 (Contract NAS5-25464)
 (NASA-RP-1080-VOL-2; REPT-81F0034-VOL-2) Avail: NTIS HC A13/MF A01

Attitude control is reviewed, encompassing the attitude control subsystem, spacecraft attitude precision pointing and slewing adaptive control experiment, and RF interferometer experiment. The spacecraft propulsion system (SPS) is discussed, including subsystem, SPS design description and validation, orbital operations and performance, in-orbit anomalies and contingency operations, and the cesium bombardment ion engine experiment. Thruster failure due to plugging of the propellant feed passages, a major cause for mission termination, are considered among the critical generic failures on the satellite. N.W.

N82-16149*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ATS-6 ENGINEERING PERFORMANCE REPORT. VOLUME 3: TELECOMMUNICATIONS AND POWER Final Report
 R. O. WALES, ed. Nov. 1981 298 p refs 6 Vol.
 (Contract NAS5-25464)
 (NASA-RP-1080-VOL-3; REPT-81F0034-VOL-3) Avail: NTIS HC A13/MF A01 CSCL 22B

Functional design requirements and in-orbit operations, performance, and anomalies are discussed for (1) the communications subsystem, (2) the electrical power system, and (3) the telemetry and command subsystem. The latter includes a review of ground support. Tracking and data relay experiments and the Apollo-Soyuz test program are reviewed. N.W.

N82-16150*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ATS-6 ENGINEERING PERFORMANCE REPORT. VOLUME 4: TELEVISION EXPERIMENTS Final Report
 R. O. WALES, ed. Nov. 1981 149 p refs 6 Vol.
 (Contract NAS5-25464)
 (NASA-RP-1080-VOL-4; REPT-81F0034-VOL-4) Avail: NTIS HC A04/MF A01 CSCL 22B

Experiments sponsored by the US Department of Health Education and Welfare are discussed, including telecommunications, Alaskan health service, Appalachian education satellite project, and the University of the West Indies. The Satellite Instructional Television Experiment in India is reviewed. Independent television experiments are addressed, including AIDSAT and Project Look Up. N.W.

N82-16151*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ATS-6 ENGINEERING PERFORMANCE REPORT. VOLUME 5: PROPAGATION EXPERIMENTS Final Report
 R. O. WALES, ed. Nov. 1981 302 p refs 6 Vol.
 (Contract NAS5-25464)
 (NASA-RP-1080-VOL-5; REPT-81F0034-VOL-5) Avail: NTIS HC A14/MF A01 CSCL 22B

Propagation experiments at 1550 MHz to 1650 MHz are reviewed, including the Integrated L-Band Experiments system and results, and the Mobile L-Band Terminals for Satellite Communication system. Experiments at 4 GHz to 6 GHz are reported, including the Radio Frequency Interferometer Measurements system and results, and Earth station antenna evaluations. Experiments above 10 GHz are discussed, including Comsat and ATS-6 millimeter wave propagation/experiments, and communication ATS-6 version at 20 and 30 GHz. N.W.

N82-16152*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ATS-6 ENGINEERING PERFORMANCE REPORT. VOLUME 6: SCIENTIFIC EXPERIMENTS Final Report
 R. O. WALES, ed. Nov. 1981 166 p refs 6 Vol.
 (Contract NAS5-25464)
 (NASA-RP-1080-VOL-6; REPT-81F0034-VOL-6) Avail: NTIS HC A08/MF A01 CSCL 22B

Evaluations include a very high resolution radiometer, a radio beacon experiment, environmental measurement experiments (EME), EME support hardware, EME anomalies and failures, EME results, and US/USSR magnetometer experiments. N.W.

N82-17235# Joint Publications Research Service, Arlington, Va.
USSR REPORT: SPACE, NO. 14
 22 Dec. 1981 79 p Transl. into ENGLISH from various Russian articles
 (JPRS-79711) Avail: NTIS HC A05/MF A01

Soviet-French and Soviet-Bulgarian cooperative space efforts are discussed. Summations of space surveys to obtain geophysical and astrophysical data, specifically ionospheric and magnetospheric observations, are reported. The status of completed biomedical programs is summarized. Descriptions of and specifications for space antennas and gamma-ray instrumentation, utilized and proposed, are given. Utilization of Earth-Moon libration points for future explorations and observations is also discussed.

N82-18275*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE SPACE SYSTEMS TECHNOLOGY, 1981
 W. J. BOYER, comp. Mar. 1982 430 p refs Presented at Third Annual Technical Review, Hampton, Va., 16-19 Nov. 1981
 (NASA-CP-2215-PT-1; L-15096) Avail: NTIS HC A19/MF A01 CSCL 22B

A total systems approach including structures, analyses, controls, and antennas is presented as a cohesive, programmatic plan for large space systems. Specifically, program status, structures, materials, and analyses, and control of large space systems are addressed.

N82-18450# Committee on Science and Technology (U. S. House).
NASA SPACE COMMUNICATIONS PROGRAM
 Washington GPO 1982 25 p Presented by the Subcomm. on Space Sci. and Appl. of the Comm. on Sci. and Technol., 97th Congr., 2nd Sess., Feb. 1982
 (GPO-85-553) Avail: Subcommittee on Space Science and Applications

A summary of NASA's space communications research and development program is provided. NASA's role in space communications, particularly in the 30/20 Gigahertz research and development program is discussed. How NASA should plan for space communications beyond 1990, and how NASA can best distribute public information concerning space communications is also discussed. R.J.F.

N82-18578*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE LASER POWER TRANSMISSION SYSTEM STUDIES
 M. D. WILLIAMS, ed. and E. J. CONWAY, ed. Feb. 1982 210 p refs Symp. held in Hampton, Va., 14-15 Oct. 1981
 (NASA-CP-2214; L-15030) Avail: NTIS HC A10/MF A01 CSCL 20E

Power transmission by laser technique is addressed. Space to Earth and space to space configurations are considered.

10 GENERAL

N82-19244# European Space Agency, Paris (France). Directorate of Administration.

SPACE ACTIVITIES IN THE 80'S: THE PROGRAMS AND THE INDUSTRY. PART 3: DETAILED PRESENTATION OF THE EUROPEAN SPACE INDUSTRY (1981)

G. DONDI Nov. 1981 535 p 3 Vol.

(ESA-SP-1012-VOL-2; ISSN-0379-6566) Avail: NTIS HC A23/MF A01; ESA, Paris FF 160 (for volume 2) FF 300 (for complete set)

The specializations, activities and potential of the space industry of ESA member countries are listed. The space firms of each country are indicated and their space activities are summarized. Contracts awarded by ESA to the firms of each country are detailed. Market guides for a number of key space/space related fields of activity, e.g., propulsion or remote sensing, are provided.

Author (ESA)

N82-19245# European Space Agency, Paris (France). Directorate of Administration.

SPACE ACTIVITIES IN THE 80'S: THE PROGRAMS AND THE INDUSTRY. PART 4: OUTLOOK OF SPACE INDUSTRY OUTSIDE EUROPE (1981)

G. DONDI Nov. 1981 260 p refs 3 Vol.

(ESA-SP-1012-VOL-3; ISSN-0379-6566) Avail: NTIS HC A12/MF A01; ESA, Paris FF 80 (for volume 3) FF 300 (for complete set)

The specializations, activities, and potential of each country are given for the American, Canadian, Japanese, and Indian space programs. Space firms in each country are indicated, and their space activities are summarized. Details of NASA contractors are provided for the U.S.

Author (ESA)

N82-19257*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

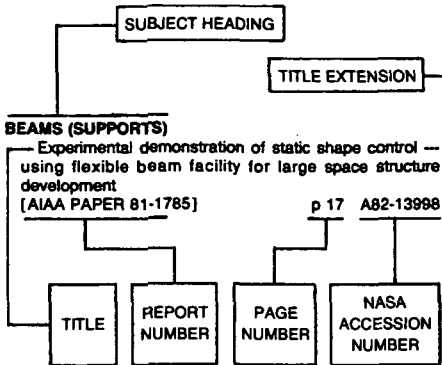
LARGE SPACE SYSTEMS TECHNOLOGY, PART 2, 1981

W. J. BOYER, comp. Mar. 1982 479 p refs Conf. held in Hampton, Va., 16-19 Nov. 1981

(NASA-CP-2215-PT-2; L-15096-PT-2) Avail: NTIS HC A21/MF A01 CSCL 22B

Four major areas of interest are covered: technology pertinent to large antenna systems; technology related to the control of large space systems; basic technology concerning structures, materials, and analyses; and flight technology experiments. Large antenna systems and flight technology experiments are described. Design studies, structural testing results, and theoretical applications are presented with accompanying validation data. These research studies represent state-of-the art technology that is necessary for the development of large space systems. A total systems approach including structures, analyses, controls, and antennas is presented as a cohesive, programmatic plan for large space systems.

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, the title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

A

ACCELERATED LIFE TESTS

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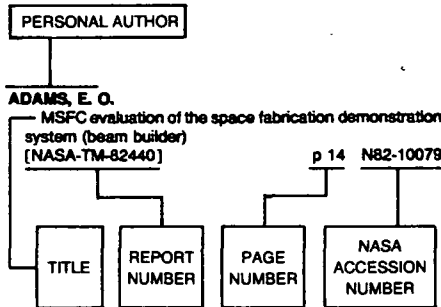
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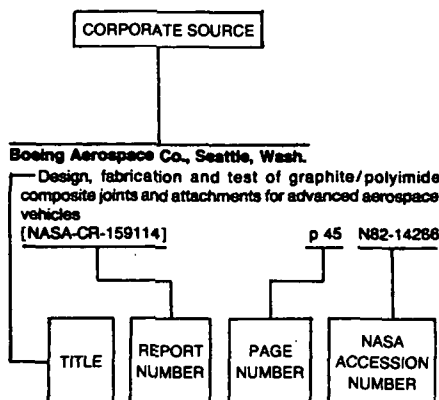
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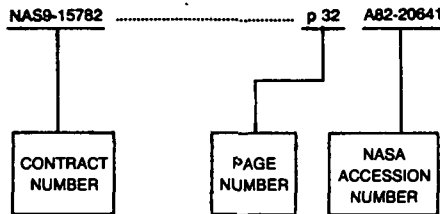
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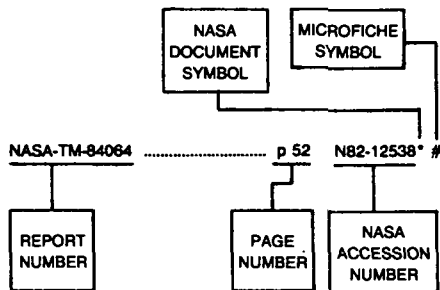
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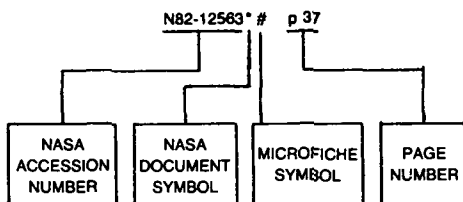
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